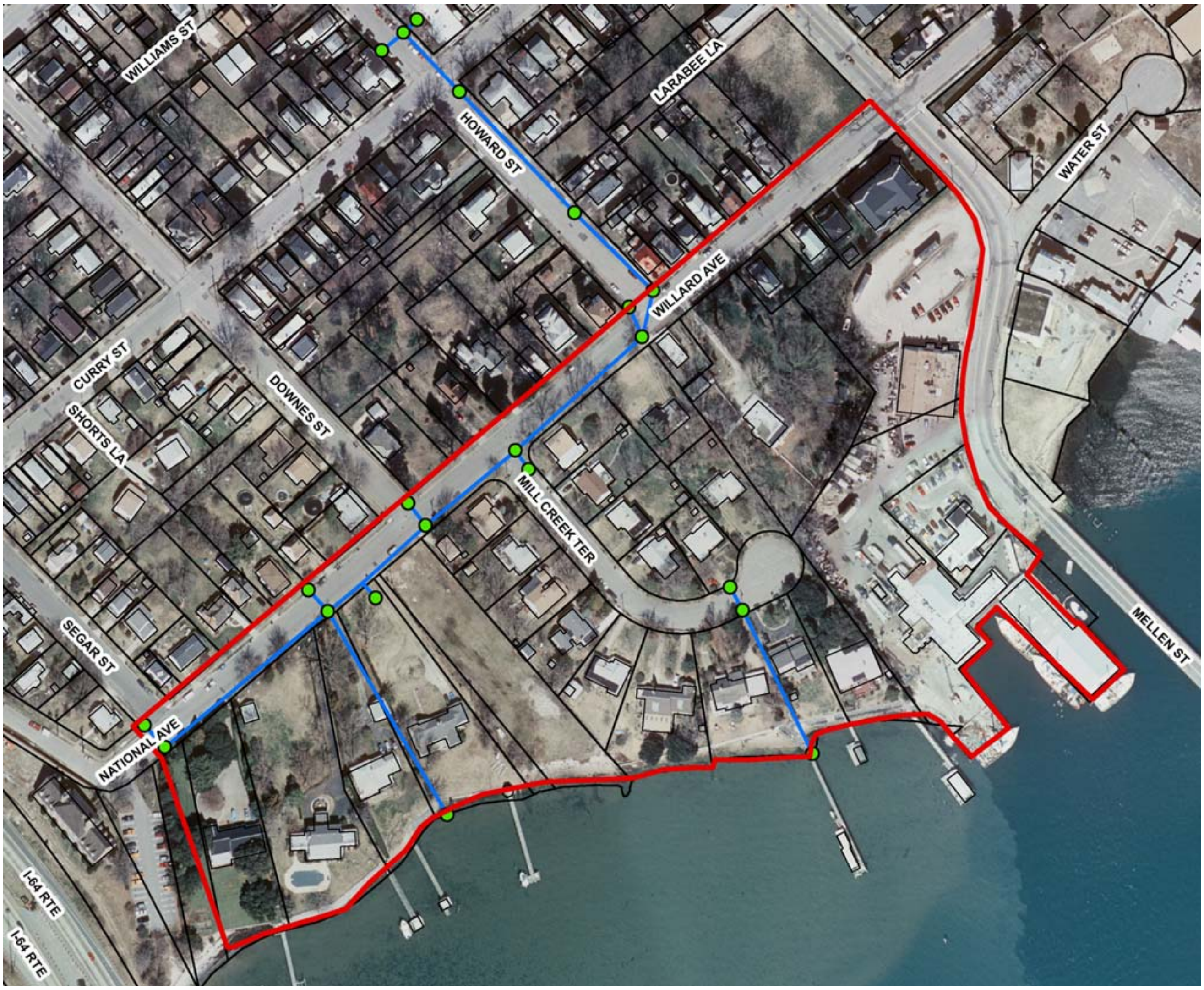
Phoebus/Mill Creek Terrace Area Drainage Study

Hampton, Virginia



February 2011

City of Hampton

URS Corporation
11658017

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Phoebus/Mill Creek Terrace Area Drainage Study- Final Report

Hampton, VA

URS No. 11658017

Purpose

The purpose of this study is to assist the city of Hampton Public Works staff in addressing concerns of the residents in the Mill Creek Terrace area of Phoebus regarding periodic flooding. This assistance included: analyzing flooding causes and effects in the Mill Creek Terrace subdivision, and along a portion of S Willard Avenue; analzying alternative solutions for mitigating the flooding; and, making recommendations of mitigation options for further consideration, in consultation with the city staff and the area residents.

Background

The Mill Creek Terrace residential area is located in the Phoebus section of Hampton, between S Willard Ave and Mill Creek, which is a tidal waterway located off of the Hampton Roads water body at the southern end of the Chesapeake Bay. Also within the drainage study area is the Wanchese Fish Company, which is located on the east side of the residential area. Over the years, there have been a number of flooding events in this area, primarily affecting the streets and yards (and a few garages), mainly due to tidal rise from the Bay/Hampton Roads/Mill Creek, which backs up into the storm drain outfalls and then rises up out of the street inlets and ponds in the streets. The tidal rise has also overtopped the Mill Creek shoreline and spread out overland across the yards and into the streets. There are two storm drain outfall pipelines into Mill Creek from the study area- one draining Mill Creek Terrace and adjacent yards (referred to on the mapping as Outfall #1), and another outfall draining a portion of S. Willard Avenue and nearby side streets, along with the adjacent yards (referred to as Outfall #2). Along the route of this second drainage outfall, there is a low area in the street, near #312 S. Willard Avenue, which experiences periodic flooding from tidal impacts as well as from storm water runoff. The Wanchese Fish Company's property does not have a typical outfall pipe line; rather, the property drains by overland flow along a concrete swale on the southwest side of the property, and then the flow discharges into a small (4") diameter pipe(through a low wall), which discharges into Mill Creek. This pipeline appears to have some sort of valve behind the wall for stopping tidal backflow(of unknown condition), but the pipe itself is clearly undersized for the volume of storm water runoff draining from the parking lot.

Some years ago, in an effort to address tidal flooding concerns, the city installed an in-line tide gate in the curb drop inlet on Mill Creek Terrace, and for a while it had some effect on preventing tidal waters from filling the storm drain and back flowing into the street, but this tide gate required too frequent maintenance and over time it did not always seal properly to prevent tidal back ups. It was later removed at the request of one of the residents. Last year, at one of the homes alongside the storm drain outfall pipeline, there was some construction work which caused the storm drain line to become blocked, and which resulted in significant street and yard flooding, after a heavy rain, with the deepest flooding occurring in the cul-de-sac at the end of Mill Creek Terrace, where the street is lowest. The city has since removed the blockage and the storm drain from the street is functioning properly, but it is still subject to tidal impacts.

In late 2010, the residents of the area approached the city about addressing these flooding problems. As a result, two meetings were held with the residents, hosted by the Phoebus Improvement League. The first meeting was attended by city staff, and the second was attended by representatives of URS and a city staff person, to discuss the concerns of the residents about flooding. Those meetings provided an opportunity for area residents to relate first hand experiences and observations about the flooding. The discussion from the November 29th, 2010 meeting with the residents was documented in a memorandum dated December 6, 2010, which is included in Appendix C. **(Also, on February 7th, a follow up meeting was held with some of the area residents to discuss the draft report and the feedback from that meeting is included in this final report.)**

Based on the citizens' input, and on field observations, it is apparent that there are two forces at work which are contributing to the flooding in the Mill Creek Terrace area. First, periodic higher than normal tides, are flowing back up into the two storm drain outfalls and/or are rising up and flowing over the shorelines/seawalls, filling the street and yards with saltwater. And, second, occasional higher intensity rainfall events, are exceeding the capacity of some of the storm drains, resulting in ponding water in the streets and yards, where the elevations are lowest. **Flooding can occur with higher tides and no rainfall, or with lower tides and a heavy rainfall; but, when there is a higher tide in combination with a heavy rainfall, the flooding potential is at its worst**. The area residents have learned to live with flooding in an extremely high tide such as during a hurricane, and they understand its inevitability – part of their frustration comes when the floodwater, be it from tidal conditions or heavy rainfall, takes an unusually long time to recede from their yards and the street, even after the tide level in Mill Creek has gone down, or after the rainfall has ceased.

It should be noted that because of the relatively low elevation of portions of the streets and the yards, there is no cost effective solution to completely eliminate neighborhood flooding in the most severe of tidal events or storms. With that constraint, this study offers options for mitigating the flooding, to the extent practicable.

Approach/Discussion:

Following the input from the area residents, and discussion with city staff, URS's first task was to determine the extent of tidal flooding from the Mill Creek water body into the Mill Creek Terrace area and along a portion of S. Willard Avenue. To do this, topographic survey information was gathered in and around the subdivision to determine the elevations of such features as garage slabs, and finished floors of houses. Spot elevations were also picked up along curbing, street centerlines, and in the yards of many of the houses in the area, and also for a portion of the Wanchese Fish Company property. This information was combined with elevation information available in the city's geographic information system, to create a topographic model of the area, based on the NAVD 1988 datum.

From this topography, a series of flood maps were prepared showing the spread of tidal flooding in 1' increments of increasing tidal height, beginning at mean seal level (MSL), up to a height of 9' above MSL (which fortunately has not been experienced to anyone's memory since the area was developed). These flood maps clearly show how the tidal water rises out of the storm drain inlets and spreads out in the cul-de-sac of Mill Creek Terrace, when the tidal height approaches 4'above MSL. At that height, the tidal water also begins to back up out of the S. Willard Ave drainage outfall and street inlets near #312, and ponding begins to occur in that street and in the nearby yards. When the tide rises above 4' MSL, ponding increases in the streets and it begins to overtop the shoreline and encroach into the rear yard of the house #10 in Mill Creek Terrace. As the tide continues to rise in Mill Creek, it spreads out into the yards, initially between # 10 and # 12 , and then it flows into Mill Creek Terrace, ponding from the end of the street (in the cul-de-sac) to approximately half way back to its intersection with S.Willard Avenue. Above a height of 4', the tidal water spreads out from the Mill Creek Terrace cul-de-sac into the adjacent yards and onto the southeast side of the adjacent Wanchese Fish Company property, covering most of the parking and storage areas adjacent to the subdivision. The waterfront homes in Mill Creek Terrace all have seawalls along the Mill Creek shoreline and these seawalls range in elevation from approximately 5' to over 6'above MSL, and on the southeast side of the Wanchese property there is a low wall at approximately elevation 5' above MSL, which blocks the tidal spread directly from Mill Creek up to the 5' elevation; however, the tidal flooding is "end running" the seawalls from the southwest. When the tidal water reaches 6' above MSL, most of the streets and yards in the study area are under water, and water flows into some garages. At 8' above MSL, tidal water begins to reach the finished floor of several of the houses in the study area. Fortunately, this height of tide has only been observed twice in the past 80 or so years.

In addition to mapping the tidal flooding effects, URS also performed a drainage analysis to determine if the existing storm drainage system was adequate to accommodate a 10-year design storm (disregarding higher than normal tidal impacts). Using the available topographic information, a determination was made of the watershed and subwatersheds from which storm water runoff flows into the drainage system along a portion of S. Willard Avenue and along Mill Creek Terrace, and then into the two existing storm drain outfalls into Mill Creek. That analysis is included in Appendix C, and it shows that the storm drainage outfall serving Mill Creek Terrace is adequate to convey the runoff from a 10-year frequency storm (which is the current standard for residential subdivisions). However, with regard to the storm drainage system along S. Willard Avenue, there are a number of pipe segments which are undersized for a 10-year storm capacity. **(This is not unusual in such areas that were built long before the city adopted design standards for drainage systems)**. A portion of the outfall pipeline from this segment of S.

Willard Avenue is not only undersized, but there are questions about its condition, and its routing, which appears to be situated under at least one structure, and it does not appear to be located in a drainage easement, which could inhibit the city's ability to maintain it or replace it in its current location.

Options Considered:

The following flood mitigation options were considered as a part of this study, generally in order of relative cost, from lowest to highest:

1) Monitor the effectiveness of the recent repairs to the Mill Creek Terrace outfall pipeline and periodically clean this outfall and outfall #2, to see if the flooding problem is sufficiently mitigated.

2) Install back flow prevention devices (tide gates or in line check valves) on the two existing storm drain outfall pipelines into Mill Creek (from Mill Creek Terrace and from S. Willard Avenue) to prevent the tide from backing up out of the storm drains and ponding in the lowest areas of the streets. Also, enlarge the outfall pipeline on the Wanchese property and replace the existing check valve on that line.

3) Construct a low (1-2') earthen berm/ levee along the rear of some of the lots in the Mill Creek Terrace subdivision. (at least behind #8 and #10).

4) Replace/enlarge the storm drain outfall pipeline from S Willard Avenue into Mill Creek- this new outfall could be relocated along the nearby adjacent vacant parcel (which the area residents refer to as the "Peng" property)

5) Replace the storm drainage pipeline segments in S. Willard Avenue as necessary to provide adequate capacity to convey a 10-year frequency storm to the outfall pipeline.

6) Reconstruct/raise the cul-de-sac on Mill Creek Terrace and a portion of the street in front of 312 S. Willard Avenue.

7) Provide a portable pump to speed up the draining of the streets, once the tidal level has receded below the elevation of the street.

8) Provide a storm water pumping station to relieve the flooding

URS has analyzed each of these options and a summary of that analysis is provided in the next section of this report. **Note: In the modeling of the storm drainage system, it is assumed that the existing drainage pipes and inlets are clean and unobstructed.** The city's Public Works drainage maintenance crews perform regular maintenance/cleaning of the storm drains and outfalls in this area as well as throughout the city. After the most recent flood incident, there was a concerted effort to recheck all of these pipelines to ensure they were free of debris and sediment. While the limited staffing of the drainage maintenance division does not allow frequent checking of the storm drainage system in any particular area of the city, the city crews will continue to monitor this area on a regular basis. In addition, reports to the 311 Call Center from citizens in the area when debris is observed or when there is flooding will help the city to keep the storm drainage system functioning up to its design capacity.

Analysis of Options

Following the identification of the options for mitigating the flooding in the Mill Creek Terrace area, as described in the previous section of this report, an analysis of those options was performed using aerial photography, mapping provided by the city staff, and computer modeling. The results of that modeling are included in Appendix C, which depict the effect of varying tidal conditions ranging from MSL to a tide 9' above MSL, on Mill Creek Terrace and on a portion of S. Willard Avenue.

Option 1) Monitor the effectiveness of the recent repairs to the Mill Creek Terrace outfall pipeline, and periodically clean this outfall and Outfall #2

Following heavy rains and significant street flooding in the area last summer, it was discovered the outfall pipeline from Mill Creek Terrace was blocked due to some adjacent construction. The city crews spent considerable time and expense to repair the damage and the pipeline is now functioning properly, as evidenced by no reports of street flooding since the repairs were made. This work has mitigated the flooding to some extent, and it may be appropriate to monitor the results of this work over the longer term before the city, or the residents, incur additional expense for further flood mitigation options. Also, it is possible that by more frequent cleaning of these outfalls, the frequency and duration of future flooding may be sufficiently diminished.

Option 2) Install Backflow Prevention Devices (Tide Gates or In Line Check Valves) on the Storm Drain Outfalls, and enlarge the storm drain outfall on the Wanchese property

The mapping showing the extent of the water spread based on varying tidal heights clearly shows that street flooding is occurring as the tide rises approaches 4'above MSL, which is the elevation of the centerline of the cul de sac at the end of Mill Creek Terrace, and which is also the elevation of the street centerline in lowest area of S. Willard Avenue. The "textbook" approach for preventing this type of tidal action is to install backflow prevention devices on the two storm drain outfalls into Mill Creek. Tide gates are a type of backflow prevention device made to prevent rising tidal waters from flowing up into storm drainage outfall lines and then flowing out of street curb inlets. Appendix D contains information on various types of tide gates in general use around the country. **However, in a shallow, flat bottomed, sediment-laden waterway such as Mill Creek, any type of tide gate will have significant maintenance issues**. The sediment in the waterway and the debris that is carried from the street into the outfall pipeline tends to hamper the proper operation of a tide gate, requiring frequent checking and cleaning. The city drainage maintenance crews have not had good long term success with any type of tide gate in water bodies such as Mill Creek. Further, the downstream ends of the storm drainage outfalls will require modification to accept a tide gate mechanism, which will complicate mobilization to the site with the necessary equipment and materials to perform this work. Such modifications will also trigger the need for state and federal permits prior to any work being performed within Mill Creek.

Several of the area residents had indicated they would be willing to monitor the tide gates operation and perhaps perform some routine maintenance to remove accumulated sediment and/or debris, which would help reduce the demands on the city's drainage maintenance crews. Unfortunately, the long term commitment of residents for voluntary maintenance has not proven to be 100% successful, particularly as current residents move away and are replaced with new residents who may not be as committed to checking the tide gates periodically. Thus, in theory, the tide gates would mitigate the flooding in this area for a certain tidal range, but in practice the long term tide gate operation is not likely to be successful due to the on-going maintenance requirements.

At the February 7th meeting with area residents, there was discussion about installing an "in line" check valve directly into the outfall storm drain pipelines, at the closest curb drop inlet to Mill Creek, to try and stop the tidal backflow. An example of such a valve, the CheckMate in line check valve, by the Tideflex Company is included in Appendix D. This device is less expensive than a "end of pipeline" tide gate, it would not require permits to install, and it should not require as much maintenance as a tide gate.

Also, on the Wanchese property, the existing small diameter pipe that serves as an outlet through the existing low wall would need to be replaced with a larger diameter (approximately 15" diameter) pipe (with a backflow preventer), to increase the flow rate of water draining off the property into Mill Creek. Currently, residents in the Mill Creek Terrace neighborhood have observed how slowly the flood waters recede from the Wanchese property, which is due in part to a "choke point" created by this small diameter outfall pipe.

Option 3) Construct a low earthen berm/levee

If the tidal rise is prevented from flowing back up the storm drain outfalls by means of tide gates, then as it rises higher it next begins to flow into the area directly from Mill Creek, by overtopping the banks along the shoreline. The lowest area of the Mill Creek Terrace subdivision is behind house #10, and the mapping clearly shows how the tide begins to flow from Mill Creek, across the vacant lot (the Peng property) and between houses #10 and 12, before advancing into the street and other nearby yards. A low earthen berm along the shoreline in this area could prevent this tidal encroachment up to a point, depending on the height and length of the berm. The shoreline elevation there is approximately 4' above MSL, and thus a 1' high berm could hold back the tide in this area until it exceeded 5'above MSL.

The precise length of this berm/levee would be dependent on how much tidal flood protection the residents/business owners were interested in achieving. From a practical standpoint, assuming the waterfront residential property owners did not want to raise the top of their seawalls, the lowest point on the seawall would determine the maximum elevation of the top of the earthen berm.

One of the negative consequences of an earthen berm would be the ponding of storm water run off in the lowest lying areas of the rear yards, behind the berm. This berm would act as a dam to prevent rear yard water from running off into Mill Creek and it would thus cause some ponding in the back yards until the storm water either percolated into the soil or evaporated. Property owners could place small diameter drain lines thru the berm with check valves to allow for the storm water to flow out to Mill Creek once the tide was below the level of their yards.

However, maintenance of these small check valves becomes critical to successfully preventing the rising tide from flowing back through the drain lines and flooding the area.

Further, the implementation of this option could be accomplished by the residents themselves, especially since the levee-type improvements would all be on private property. Another consideration is the fact that all of the property owners with the lowest rear yards would need to cooperate in the placement of the berm in order for it to be effective in mitigating tidal flooding for the neighborhood, to prevent the tide from “end running” the berm to flow into the neighborhood. Perhaps the Phoebus Civic Association could serve as an intermediary for discussions among the property owners upon whose property these levee-type improvements would be needed to improve the area’s protection from overland tidal flooding.

Option 4) **Replace the Storm Drain Outfall from S. Willard Avenue**

Based on drainage calculations performed on the watersheds and storm drainage system in this area, a portion of the existing drainage outfall from S. Willard Avenue is not adequately sized to accommodate a 10-year frequency storm, which is the current design standard for residential storm drainage (older areas of the city such as Phoebus, Wythe and Downtown Hampton typically have drainage systems with less than a 10-year storm capacity). When this intensity of a rainfall does occur, this pipeline capacity deficiency causes storm water to back out of the curb and yard inlets along the outfall and the storm water then ponds in the street and yards in the vicinity of #312 S. Willard, until such time as the rainfall stops and the flow rate recedes to a level that the outfall pipeline can convey the remaining ponded storm water out to Mill Creek.

This can take a period of hours depending on the intensity of the rain and the height of the tide.
The existing storm drain outfall route from S Willard to Mill Creek appears to be under at least one structure and it is not believed to be in an easement, thus it would be advisable to relocate it, if it is replaced. There is a vacant lot to the northeast of the existing outfall along which the new storm drain line could be placed, **subject to the acquisition of an easement from the property owner**, and assuming there is adequate depth/cover for the pipe. This would also require the replacement of approximately 200’ of storm drain line along S. Willard Avenue, from the present outfall location to the new outfall location.

Option 5) Replace the storm drain lines in S. Willard Ave to provide a 10-year storm capacity.

This option would increase the capacity of the storm drainage system in S. Willard Avenue to convey storm water and thereby reduce the frequency of flooding. And, when flooding does occur as result of a much higher intensity storm, it would reduce the duration on any ponding in the streets and yards. Currently, the flow in these storm drains backs up during a 10-year storm event and the overflow rises up out of the curb inlets and flows down the street to the low spot in front of 312 S. Willard Avenue. If the lines were replaced with larger pipes in order to obtain a 10-year storm capacity, the frequency and duration of these overflows would be diminished. **It should be noted that this option is predicated on the outfall pipeline being replaced first, otherwise the back up of storm water would continue at its current location on S. Willard**

Avenue. In fact, this option by itself would worsen the flooding since the flow of storm water down to the low area would increase with the larger upstream pipes.

Option 6) Reconstruct street segments and elevate the streets and adjacent yards

The centerline of the cul-de-sac at the end of Mill Creek Terrace is approximately at elevation 4' above MSL, as it is the low area of Willard Avenue, in front of house # 312. Any tidal events that exceed that elevation will cause street flooding (without tide gates on the outfalls). The only method of permanently eliminating this street flooding is to reconstruct the roads at a higher elevation. The city of Norfolk is in the process of raising one of its streets in the Ghent neighborhood in order to reduce the number of times it floods due to tidal action. However, this is not only an expensive option, it also creates the need to replace driveway aprons and sidewalks, Further, yards would have to be regraded to slope away from the street, rather than toward the street, as they currently do. Additional storm drains and earth swales (very shallow ditches) would also be required to catch the yard drainage and convey it to the storm drain pipelines in the street. This would be extremely disruptive to the houses adjacent to the elevated street sections, and the benefits gained would be difficult to justify considering the high cost.

Option 7) Provide a portable pump to accelerate the draining of ponded waters (once the tide receded)

At the meeting with the residents in late 2010, a citizen suggested that if a portable pump was made available to the residents during a flood, they could take charge of setting it up and running it after a flood to pump flood waters back out to Mill Creek and thereby reduce the duration of the flood (assuming the tide had gone down below the flood level). While the idea of self-help is commendable, this option is likely unworkable, given the extent of tidal flooding citywide and the city's inability to be able to service the many neighborhoods that would want to be provided equal access to large pumping equipment. Further, if other options above are implemented, then the flood waters should recede faster than is currently happening, without additional pumping equipment.

Option 8) Construct a permanent storm water pumping station in the area.

Storm water pumping stations are relatively rare in the Hampton Roads area, primarily because of their very high initial cost and long term operating/maintenance costs. The city of Virginia Beach has used a few such stations along portions of its oceanfront. Cities such as New Orleans and Savannah also make use of these stations where the real estate costs are significantly higher and the flood risk to structures is much greater. (Large areas of these cities are below sea level). Storm water pumping stations require a large area for storm water to accumulate and then the water is "sucked" into large pumps and "pushed" through pipes to a downstream area. Based on the high life cycle cost for a storm water pumping station, and the relatively small area of flooding in and around the study area, a storm water pumping station is not a cost effective solution and therefore it is recommended that this not be given further consideration for this area.

Recommendations of Options for Further Consideration:

The Mill Creek Terrace area will always be susceptible to periodic flooding primarily due to its relatively low topography. Given those circumstances, the best solution for mitigating future flooding is to consider implementing as many practicable flood mitigation options as is possible. To that end, the following options are recommended for further consideration by the city and the citizens:

1) **Monitor the effectiveness of the recent repairs to the Mill Creek Terrace outfall pipeline, and periodically clean this outfall and Outfall #2.** This work has mitigated the flooding to some extent, and it may be appropriate to monitor the results of this work over the longer term before the city, or the residents, incur additional expense for further flood mitigation options. Also, it is possible that by more frequent cleaning of these outfalls, the frequency and duration of future flooding may be sufficiently diminished. **The area residents can support this effort by observing and reporting any problems with debris in the storm sewer inlets, and through improved "housekeeping" by keeping yard debris out of the streets before it is carried into the storm drains by runoff.**

2) **Provide tide gate devices on the ends of the two existing storm drain outfall pipelines into Mill Creek, or install in-line check valves on the downstream side of the roadside curb drop inlets (closest to Mill Creek) , to prevent the backflow of rising tidal waters into the streets, and replace the drainage outfall pipeline from the Wanchese property**. Due to the low elevation of the portions of the streets that are experiencing the most frequent flooding, unless the tide is held back between 4'above MSL until it rises up to the height of the shoreline, the current street flooding is a certainty in Mill Creek Terrace and in S. Willard Avenue.. Although tide gates/check valves create potential operational and maintenance problems, they are the "first line of defense" from tidal flooding in the streets, until the tide rises higher than the shoreline and then spreads overland into the streets. Because some modification of the end of the drainage pipelines in Mill Creek is necessary to install a tide gate, federal and state permits will be required for this work. **(However, permits would not be required for an in line check valve).**
   Also, the small diameter pipeline draining the Wanchese parking lot should be replaced with a 15" diameter pipeline, including a check valve to stop tidal backflow. Because this drainage outfall is on private property, and because it does not drain a public street, (except when the Mill Creek Terrace cul de sac overflows on the Wanchese property), replacement of this pipeline with public funds may be more difficult to justify.

3) **Install a low earthen berm behind #10 and #8 Mill Creek Terrace to provide more protection from tidal encroachment.** This area is approximately two feet lower than the seawall behind house #12, and tidal waters are currently flowing overland through this area to reach the street. Additional topographic and design work would be necessary in order to determine the precise limits of the berm for maximum effectiveness. If the new

drainage outfall is installed along the east side of the Peng property, per option #4, then this berm could be created with fill during the backfill over the new outfall.

4) **Replace the undersized storm drain outfall from S Willard Avenue, out to Mill Creek**. Ideally, the new pipeline should be rerouted along the vacant lot (Peng property) within a 15’ wide drainage easement (**which would need to be acquired**). Note: there is an existing 10’ drainage and utility easement along the rear of the Mill Creek Terrace subdivision lots but this is encumbered with fences, trees, sheds and other features which make it more difficult to use as a pipeline corridor. The new pipeline should be a 48“diameter (or equivalent non-circular pipe to handle the run-off from a 10 year frequency storm.

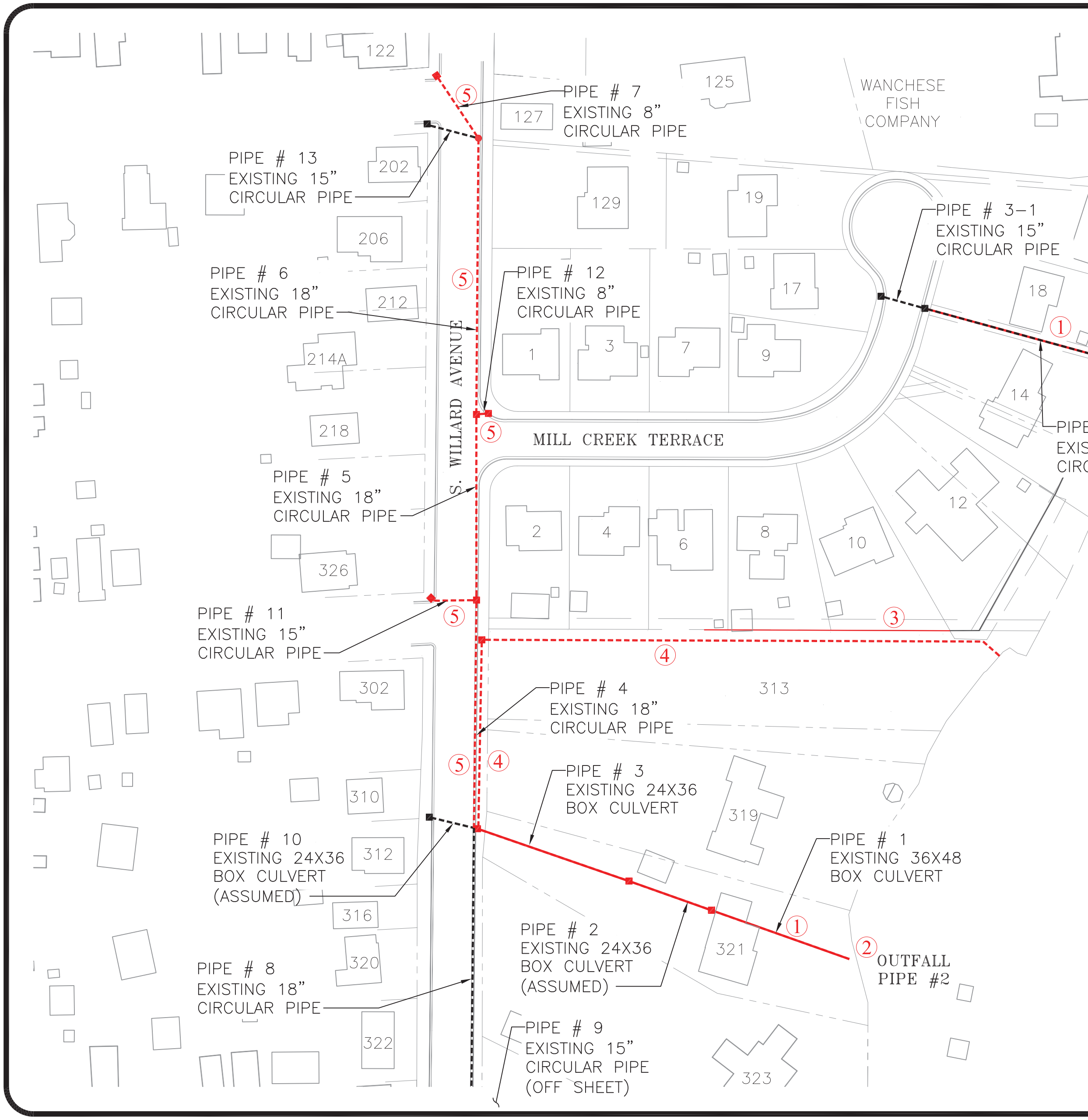
5) Replace undersized storm drain pipeline segments in S. Willard Avenue, as depicted on the mapping in Appendix C. These lines are undersized for a 10-year frequency storm. **A table depicting the estimated pipe sizes needed for a 10-year storm capacity is also included in Appendix C.**

Options 6, 7 and 8 were not recommended for further consideration because they were either not cost effective or not practical. Since Option #1 has already been implemented, the city could then take a “wait and see” approach on the other recommendations, to determine if the flooding problem is sufficiently diminished such that no further drainage improvements are necessary. **If flooding does continue undiminished in the area, then Option #2 could be implemented, and so on, in a sequential manner as funding becomes available.**

Also, there was no consideration given in this report to possible means of reducing the structural flooding potential to garages and houses in the study area, since the primary concern of the area residents was mitigating street and yard flooding. There is a wealth of information available on-line concerning structural flood proofing measures which property owners can access, ranging from temporary flood gates in front of garage openings to raising the finished floor of houses.

Any of the above options would reduce the frequency and duration of flooding in the Mill Creek Terrace area. Certainly there should be further dialogue between the area residents and the city to weigh the pros and cons of each option in order to determine each party’s role and funding availability/cost sharing of any agreed upon options for implementation. **To facilitate these discussions, a graphic depicting Options 1-5 follows this page, along with conceptual cost estimates for Options 2-5.** Should the group wish to pursue any of these options, URS stands ready to assist the group with any design needs.

URS would like to acknowledge the city staff and others who assisted with this study, including Lynn Allsbrook, Director of Public Works, Tom Crispell, Engineering Technician, Chuck Fleming, Storm Water Engineer, Kevin Gallagher, Public Works Analyst, Pat Ray, Drainage Maintenance Superintendent, Jim Turner, Executive Director of the Phoebus Improvement League, and the residents of the study area who attended the November 29th, 2010 meeting to share their experiences and observations of the flooding.



FLOOD MITIGATION OPTIONS RECOMMENDED FOR FURTHER CONSIDERATION

1. MONITOR/KEEP OUTFALL PIPES CLEAN
2. INSTALL TIDE GATES ON OUTFALL #1 AND #2
3. CONSTRUCT LEVEE
4. RELOCATE OUTFALL #2
5. UPSIZE STORM DRAINAGE LINES

*ELEVATIONS BASED ON NAVD 88

CITY OF HAMPTON
DEPT. OF PUBLIC WORKS
22 LINCOLN STREET
HAMPTON, VIRGINIA
23669
TEL: 757-727-6390
FAX: 757-727-6123

Date:	2/2011
Survey:	A.D.P.
Design:	B.R.A.
Drawn:	B.R.A.
Checked:	J.F.W.

REVISIONS

Date	By	Descriptions

PHOEBUS/MILL CREEK TERRACE AREA DRAINAGE STUDY

FLOOD MITIGATION OPTIONS RECOMMENDED FOR FURTHER CONSIDERATION

Hampton
AMERICA'S FIRST

Mill Creek Terrace Area Drainage Study- Conceptual Cost Estimates
February, 2011

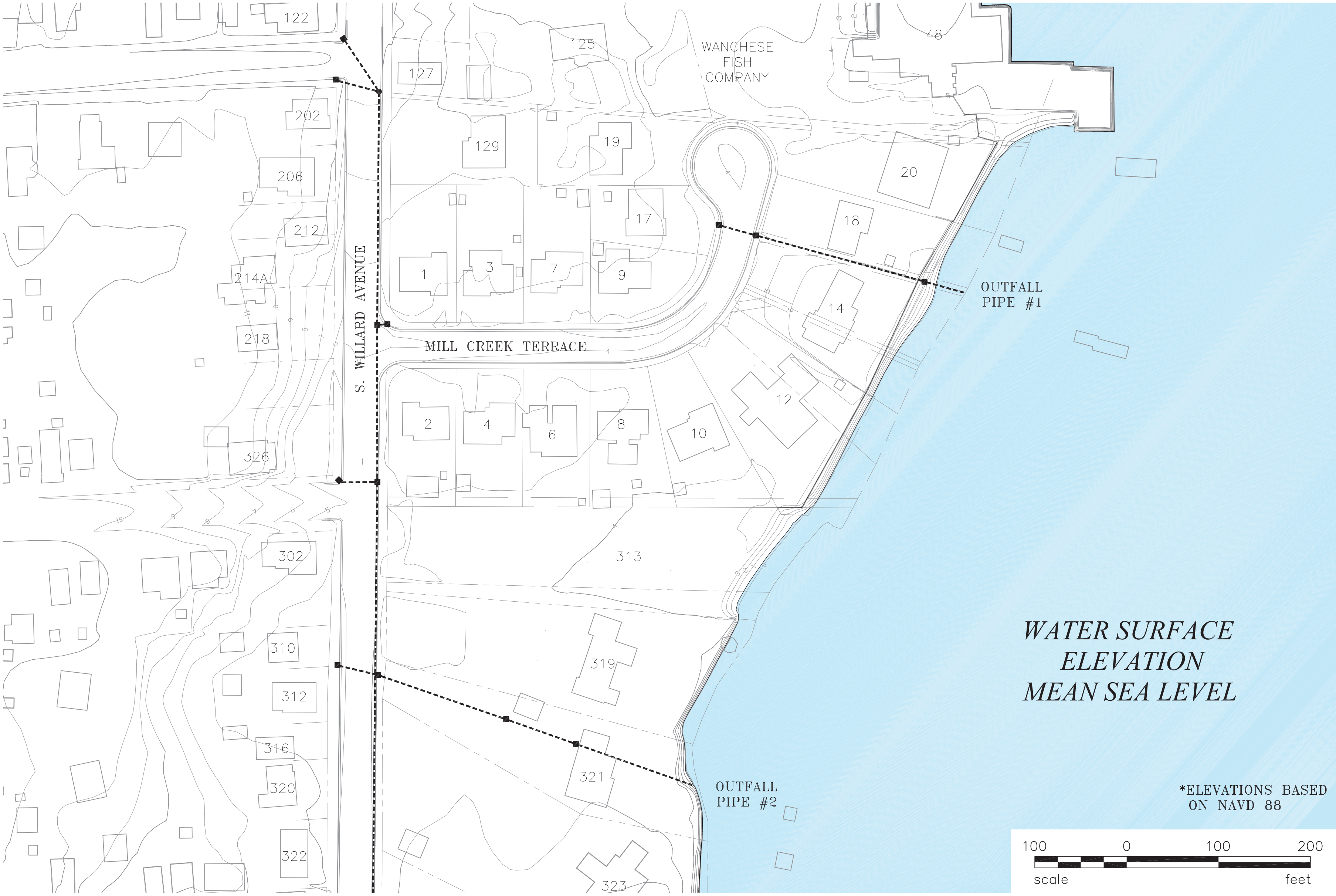
Elements / Options	2)Tide Gates	3) Levees	4) New Outfall	5) Larger Pipes
Replace Pipe Segments in Mill Creek	$40k			
Tide Gates (flappers)	$25k		$15k	
Manholes behind gates for access	$20k		$10k	
Upsize Wanchese outfall pipe	$5K			
Select Fill/grading/seeding		$25k		
Check valves on small drains thru levee		$5k		
500' +/- 48" dia concrete pipe			$75k	
200' +/- 18" dia concrete pipe			$20k	
500' =/- avg 27" concrete pipe				$75k
pavement replacement				$25k
Totals	$90K	$30K	$120K	$100K

Notes: **Option 2, if in line check valves are used instead, would be approximately $25k**
Option 3 work is on private property and could be considered ineligible for public funding
Option 4 does not include the cost of a drainage easement across the Peng property
Options 6-8 not estimated at this time

Appendix A

Tidal Flood Maps

Sheets 1-11



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22 LINCOLN STREET
HAMPTON, VIRGINIA
23669
TEL: 757-727-6390
FAX: 757-727-6123

Date: 2/2011
Survey: A.D.P.
Design: B.R.A.
Drawn: B.R.A.
Checked: J.F.W.

Date	By	Descriptions

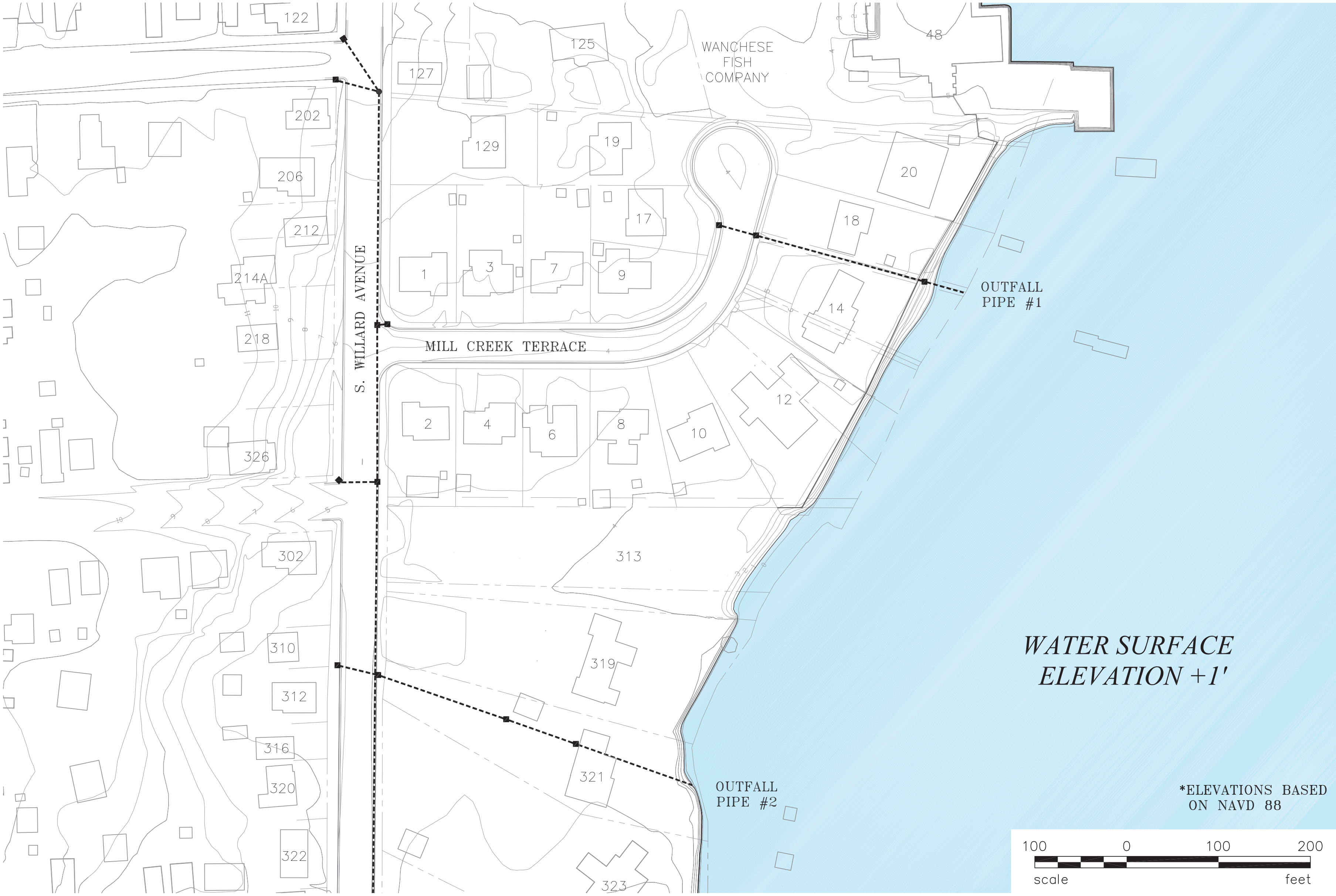
REVISIONS

PHOEBUS/MILL CREEK TERRACE
AREA DRAINAGE STUDY

WATER SURFACE ELEVATION
MEAN SEA LEVEL

Hampton
AMERICA'S FIRST

Sheet 1



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FAX: 757-727-6123

Date: 2/2011
Survey: A.D.P.
Design: B.R.A.
Drawn: B.R.A.
Checked: J.F.W.

Date	By	Descriptions

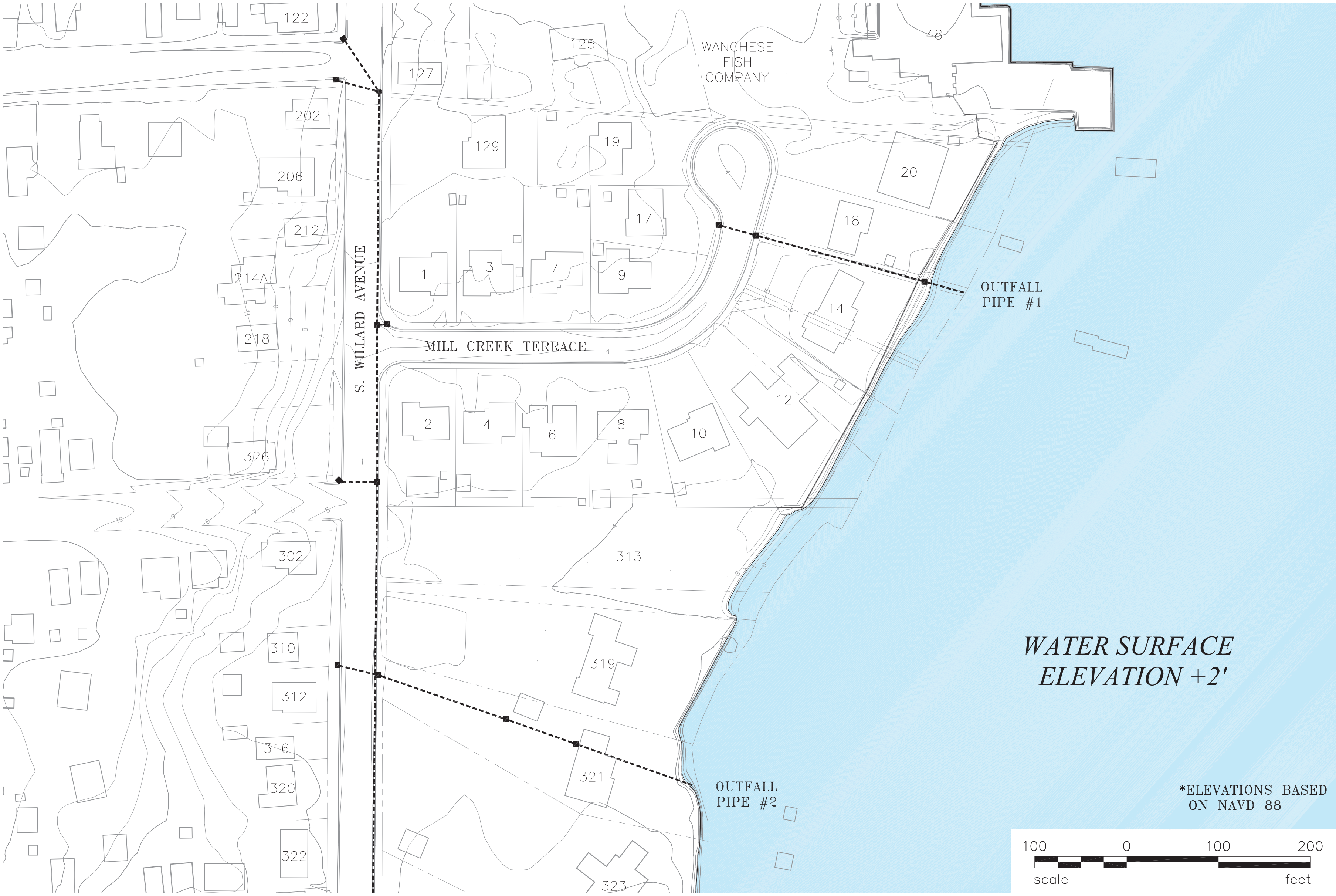
REVISIONS

PHOEBUS/MILL CREEK TERRACE
AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +1'

Hampton
AMERICA'S FIRST

Sheet 2



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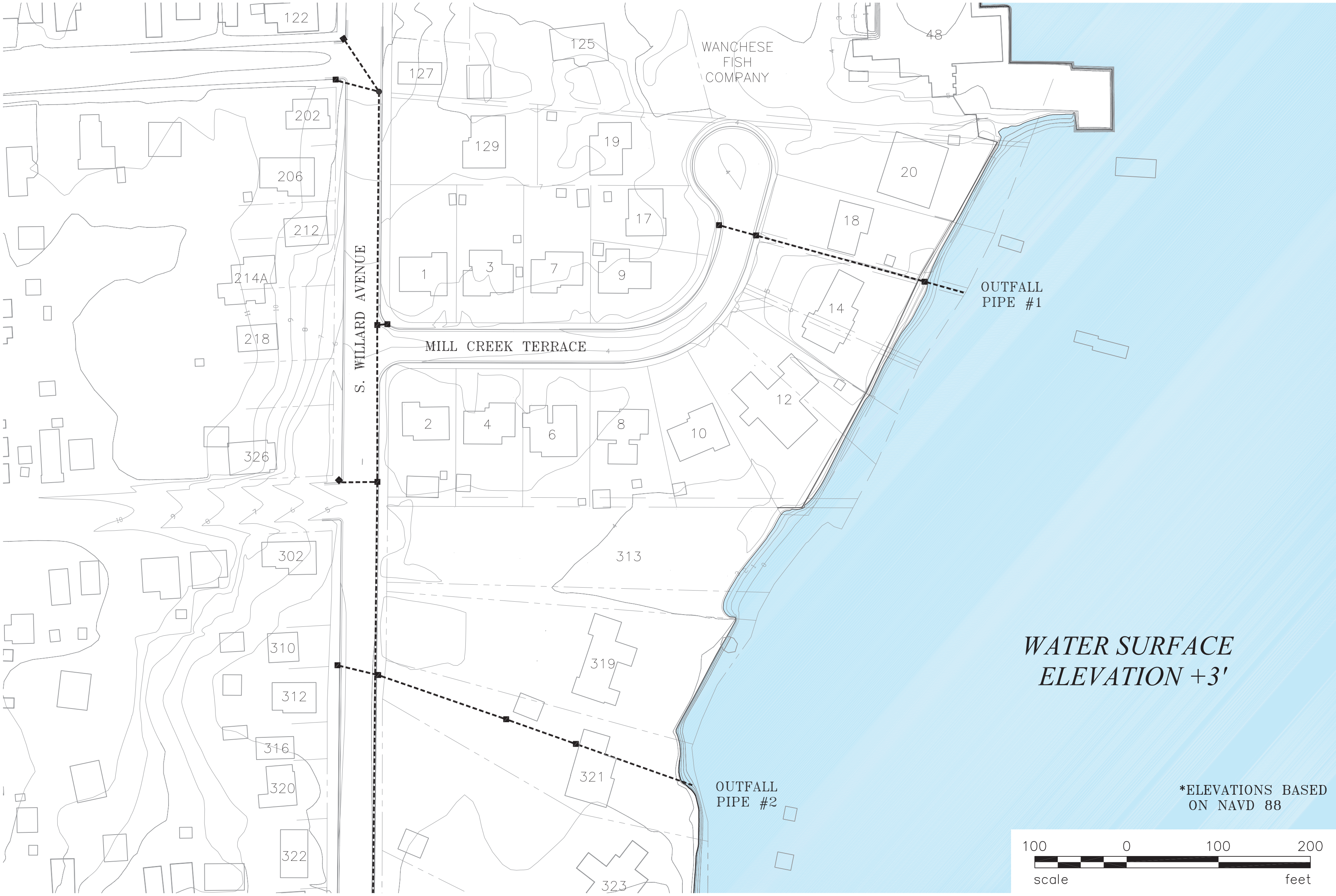
Date	By	Descriptions

PHOEBUS/MILL CREEK TERRACE AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +2'

Hampton
AMERICA'S FIRST

Sheet 3



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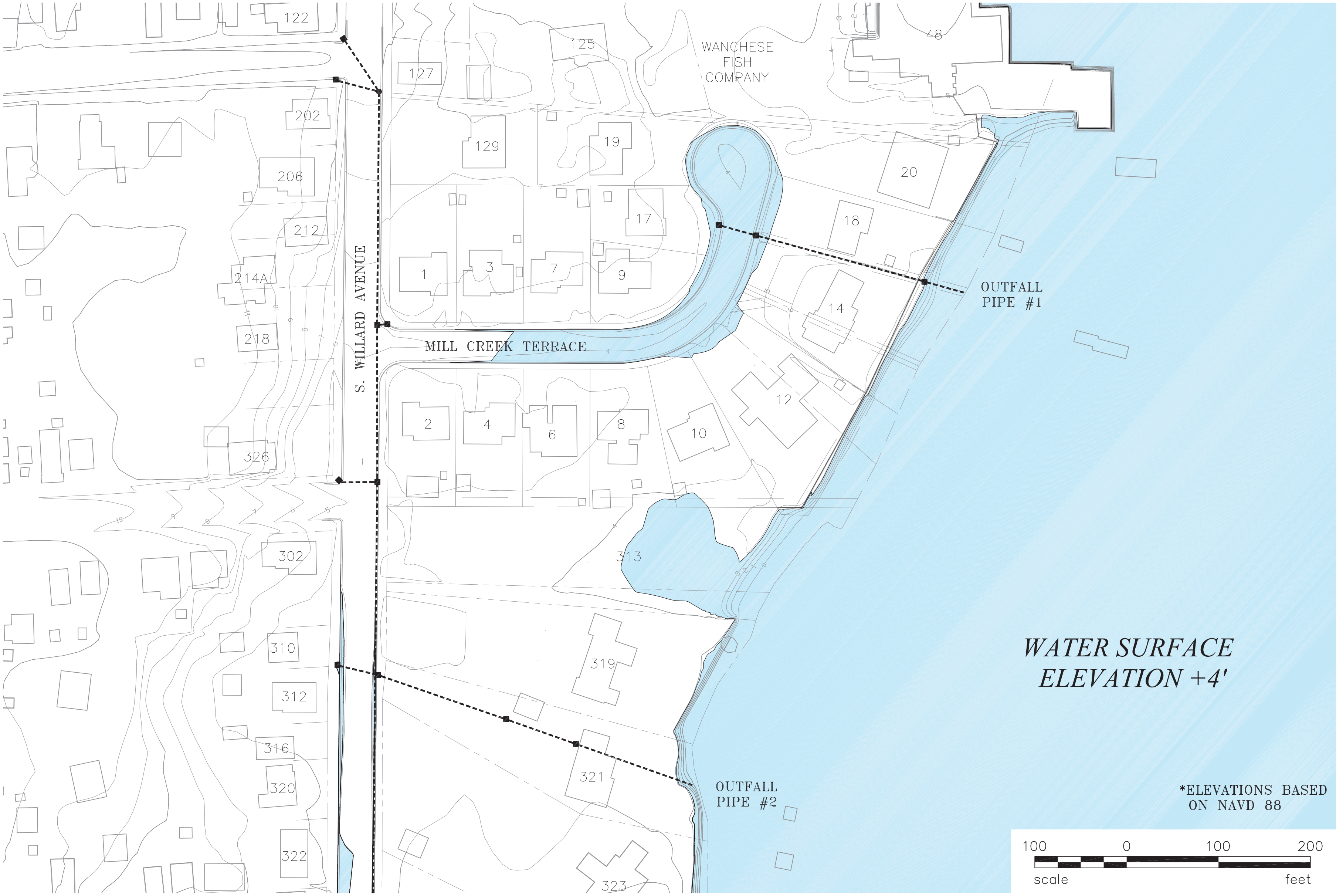
PHOEBUS/MILL CREEK TERRACE
AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +3'

Hampton
AMERICA'S FIRST

Sheet 4



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REVISIONS

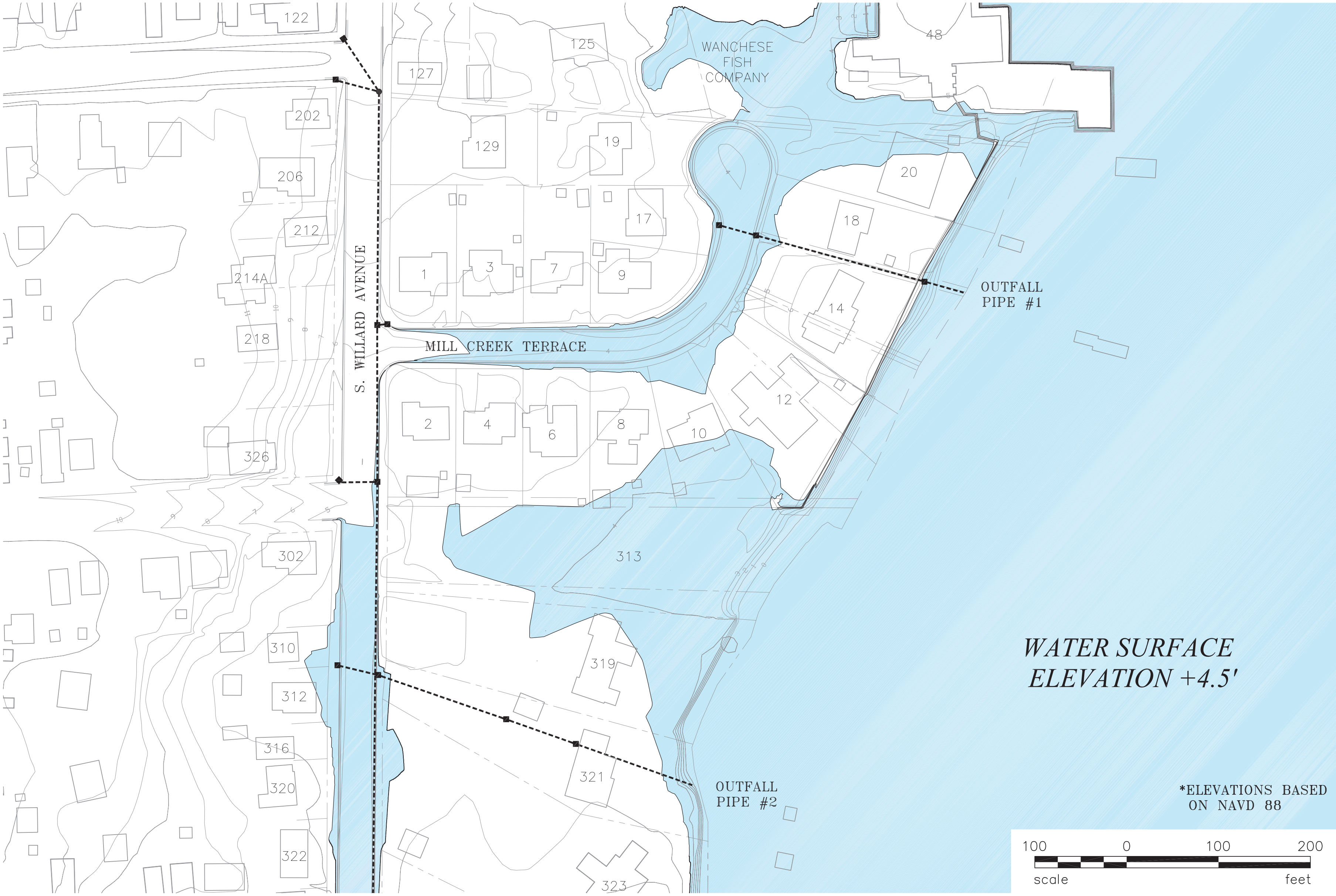
Date	By	Descriptions

PHOEBUS/MILL CREEK TERRACE
AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +4'

Hampton
AMERICA'S FIRST

Sheet 5



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Date	By	Descriptions

PHOEBUS/MILL CREEK TERRACE
AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +4.5'

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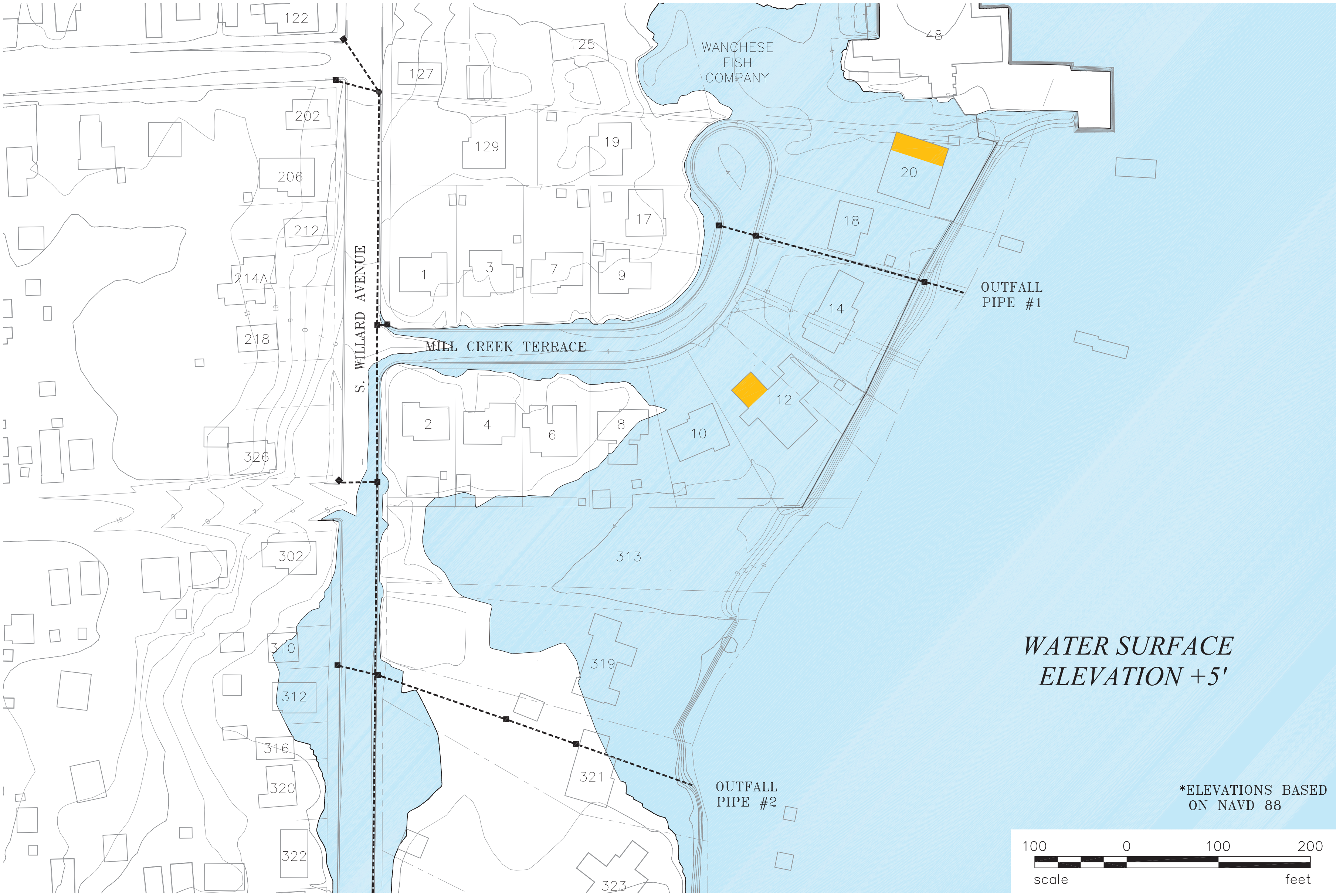
Sheet 6



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Date: 2/2011
Survey: A.D.P.
Design: B.R.A.
Drawn: B.R.A.
Checked: J.F.W.

Date	By	Descriptions

REVISIONS

PHOEBUS/MILL CREEK TERRACE
AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +5'

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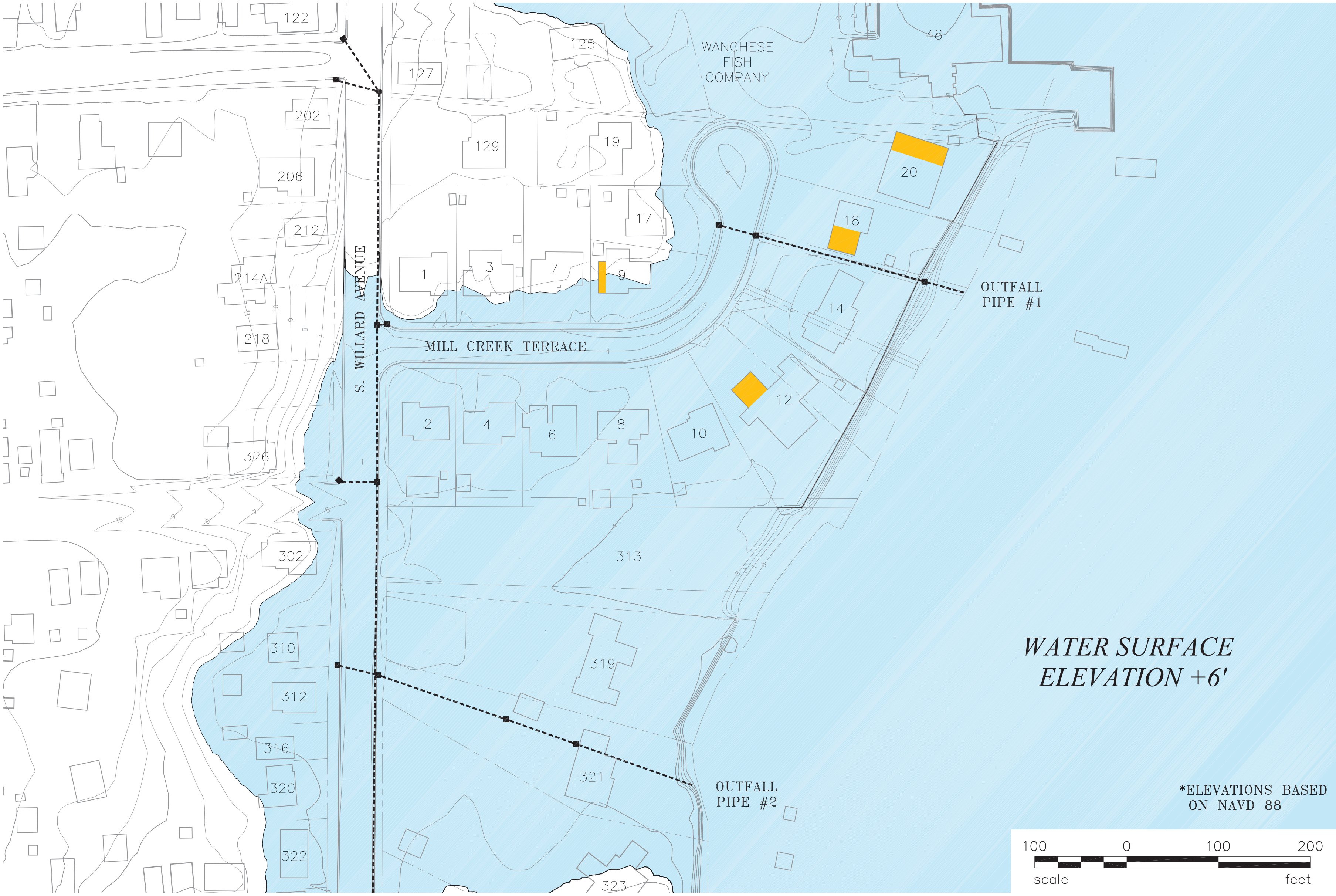
Sheet 7



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Date	By	Descriptions

PHOEBUS/MILL CREEK TERRACE
AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +6'

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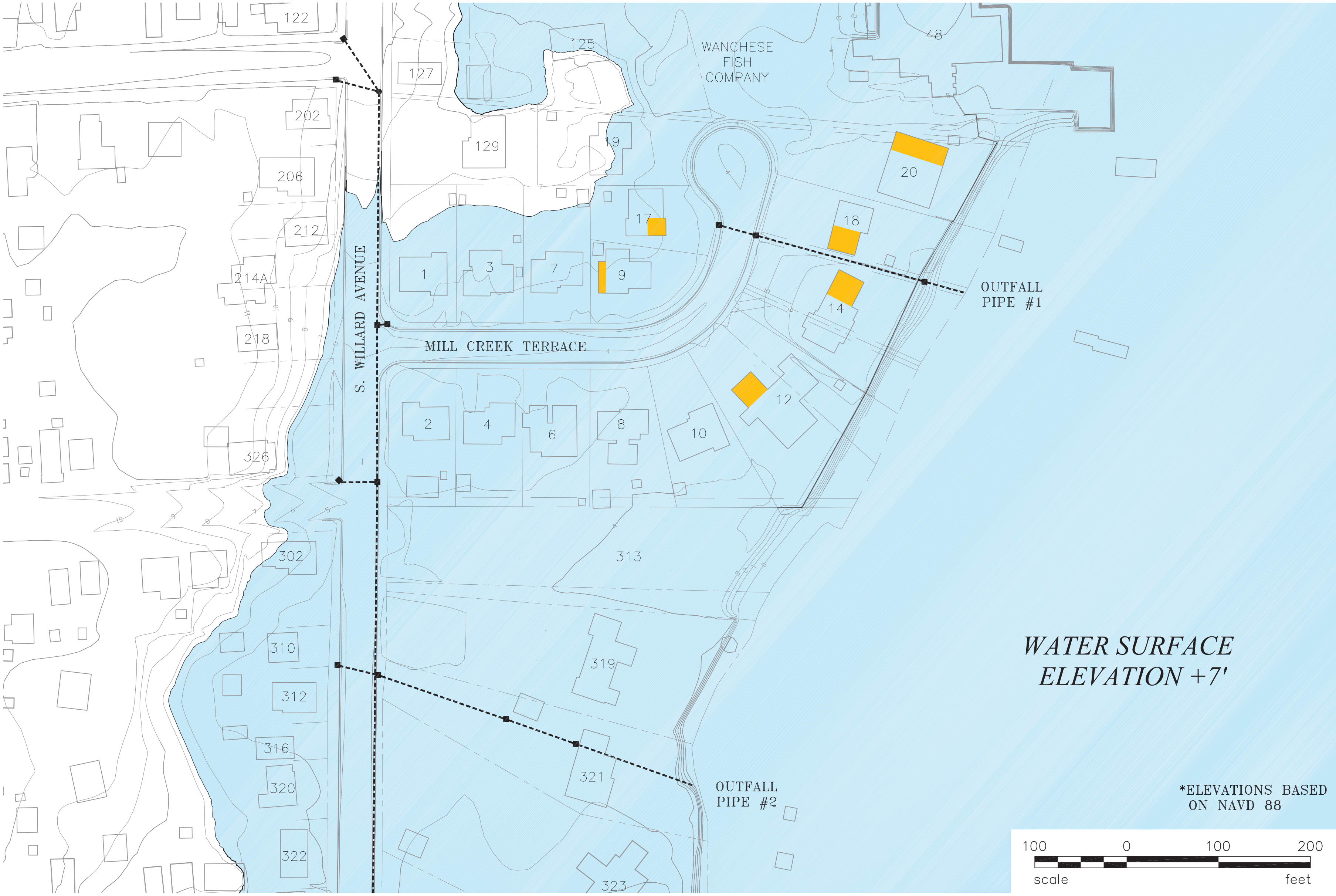
Sheet 8



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Date	By	Descriptions

PHOEBUS/MILL CREEK TERRACE AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +7'

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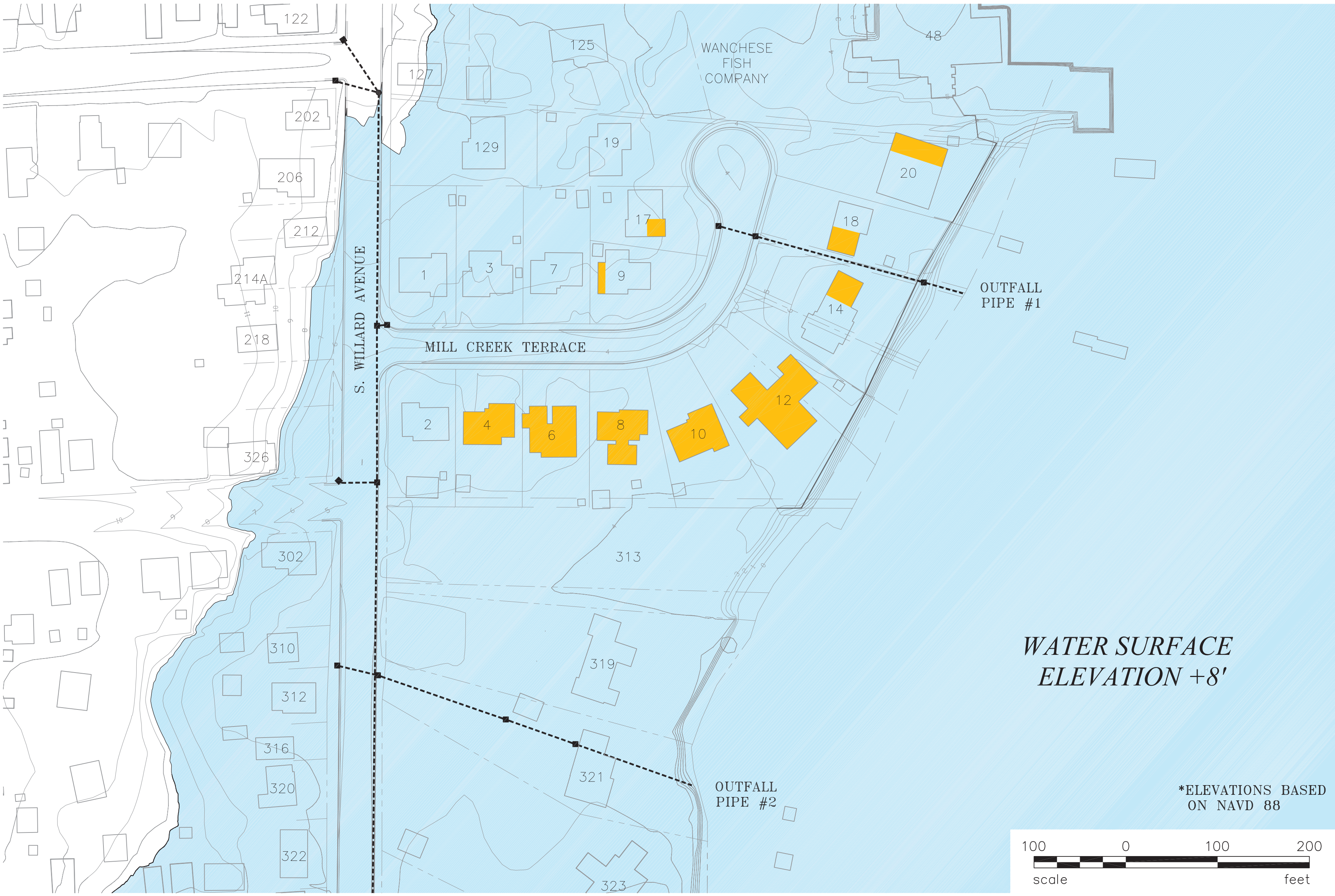
Sheet 9



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REVISIONS

Date	By	Descriptions

PHOEBUS/MILL CREEK TERRACE AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +8'

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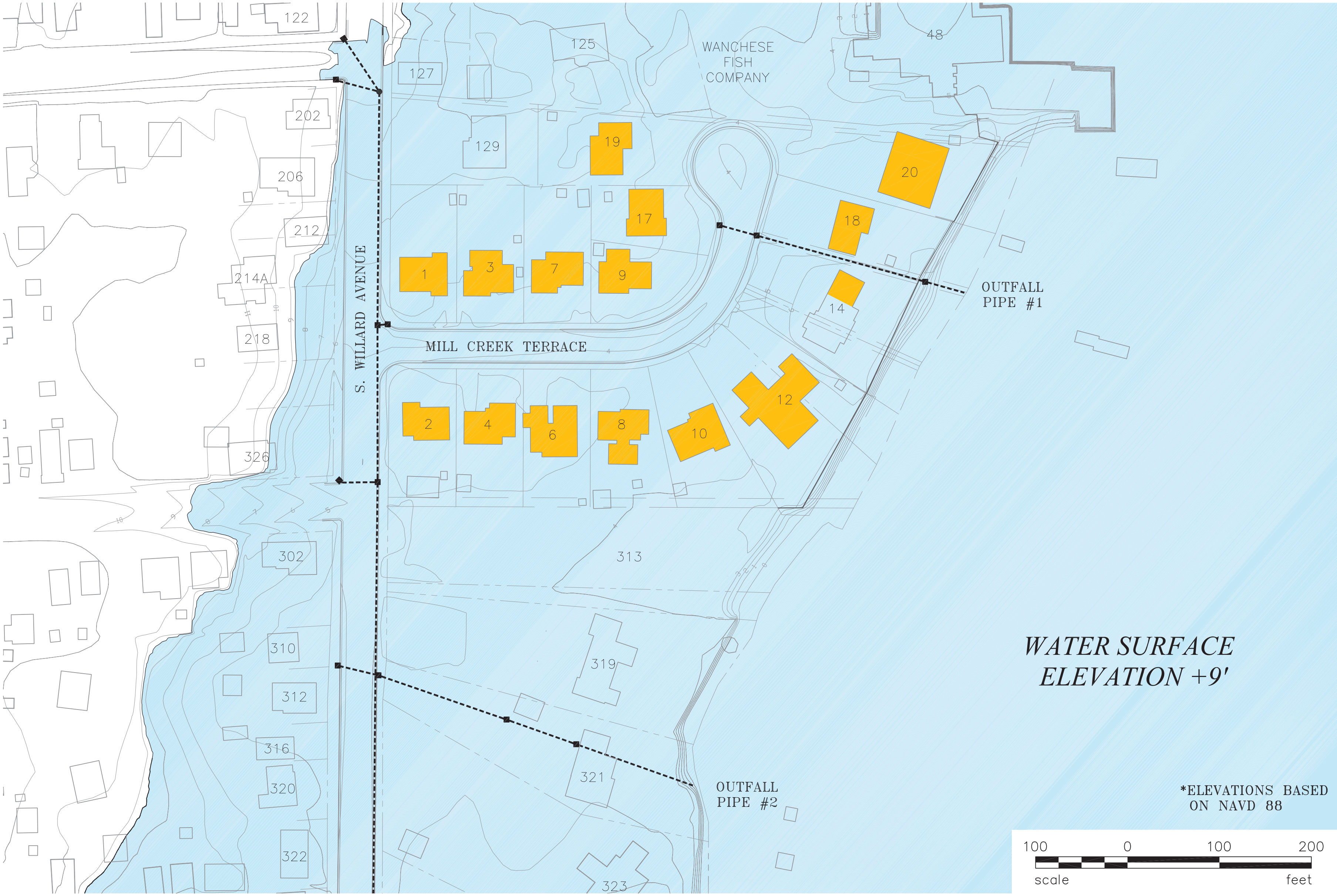
Sheet 10



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Date	By	Descriptions

PHOEBUS/MILL CREEK TERRACE AREA DRAINAGE STUDY

WATER SURFACE ELEVATION +9'

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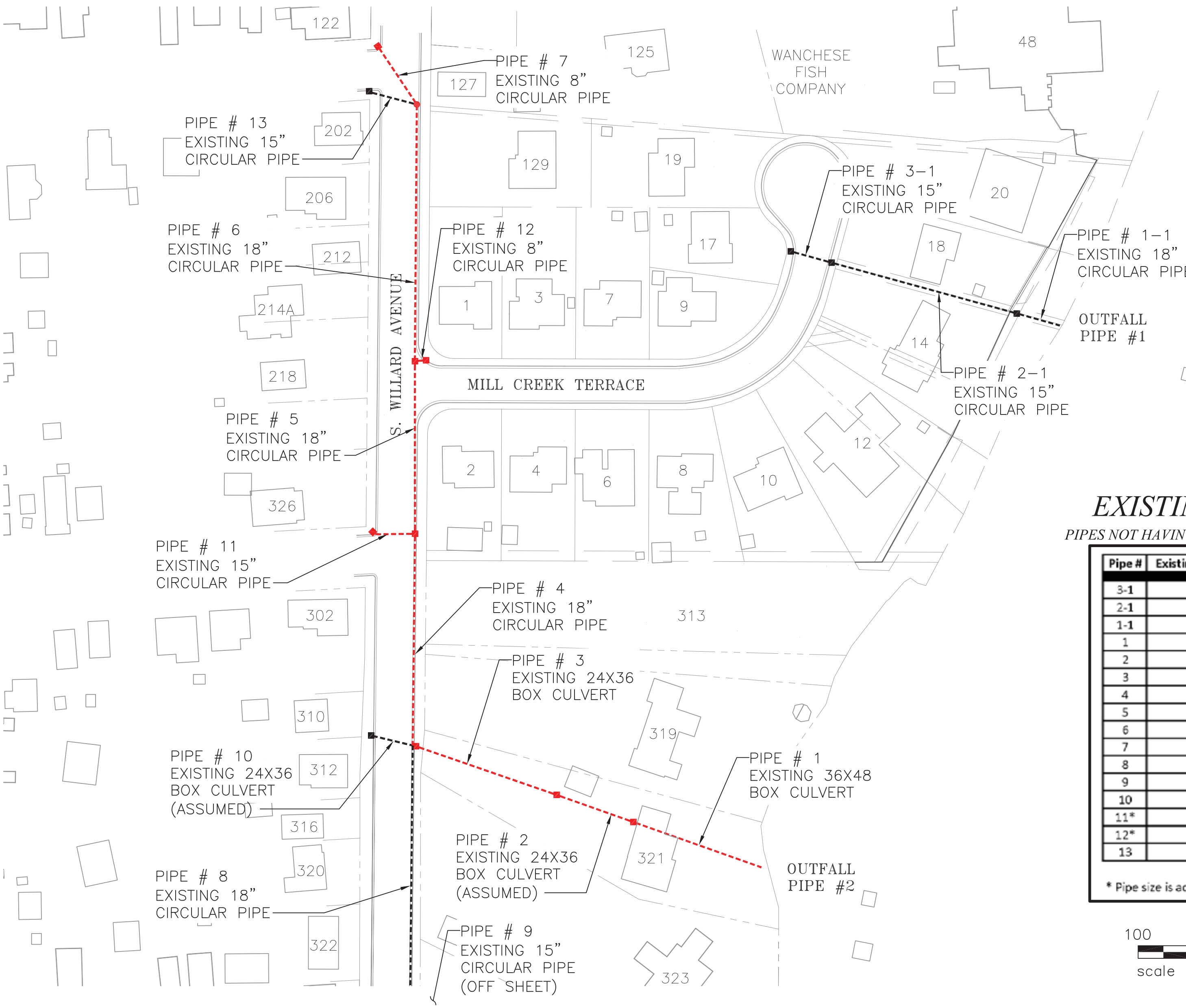
Sheet 11

Appendix B

Storm Drainage Modeling Results

- **Storm Drains not having 10 Year Storm Capacity**
- **Drainage Calculations**



EXISTING PIPE NETWORKS

PIPES NOT HAVING 10 YEAR STORM CAPACITY SHOWN IN RED

Pipe #	Existing Pipe Size	Size Required for 10 Year Storm
3-1	15"	15"
2-1	15"	15"
1-1	18"	18"
1	36x48	36X48
2	24x36	36X48
3	24x36	36X48
4	18"	30"
5	18"	30"
6	18"	24"
7	15"	24"
8	18"	18"
9	15"	15"
10	24x36	24X36
11*	15"	15"
12*	8"	8"
13	15"	15"

* Pipe size is adequate. Additional slope is required.

100 0 100 200
scale feet

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PHOEBUS/MILL CREEK TERRACE
AREA DRAINAGE STUDY

EXISTING PIPE NETWORKS
WITH SUGGESTED PIPE SIZES

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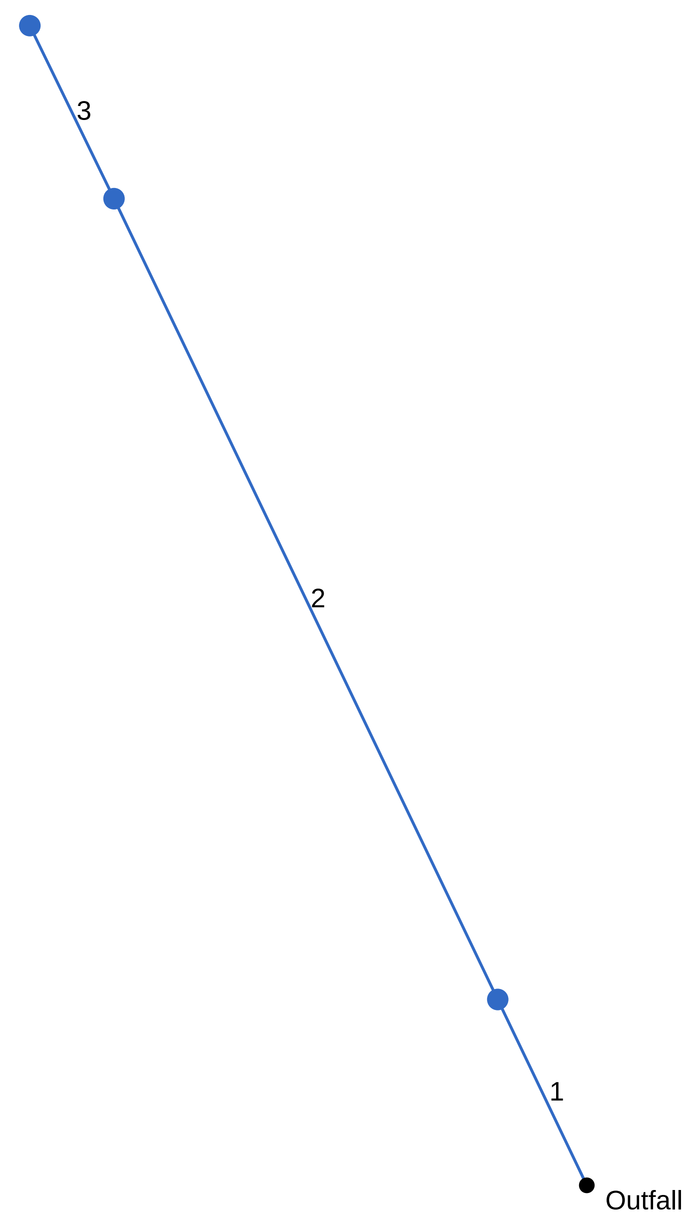
Sheet 12

Hydraflow Storm Sewers Extension for AutoCAD® Civil 3D® 2008 Plan



Project File: System_Creek_Terrace.stm	Number of lines: 3	Date: 01-28-2011

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr line No.	Line length (ft)	Defl angle (deg)	Junc type	Known Q (cfs)	Drng area (ac)	Runoff coeff (C)	Inlet time (min)	Invert El Dn (ft)	Line slope (%)	Invert El Up (ft)	Line size (in)	Line shape	N value (n)	J-loss coeff (K)	Inlet/ Rim El (ft)	
1	End	44.000	-115.436	MH	0.00	0.00	0.00	0.0	-0.98	2.77	0.24	18	Cir	0.013	0.15	3.39	
2	1	190.000	-0.250	MH	0.00	1.31	0.45	14.0	0.24	0.19	0.60	15	Cir	0.013	0.15	3.34	
3	2	41.000	0.160	MH	0.00	1.28	0.45	25.0	0.53	0.37	0.68	15	Cir	0.013	1.00	3.28	

Project File: System_Creek_Terrace.stm | Number of lines: 3 | Date: 01-28-2011

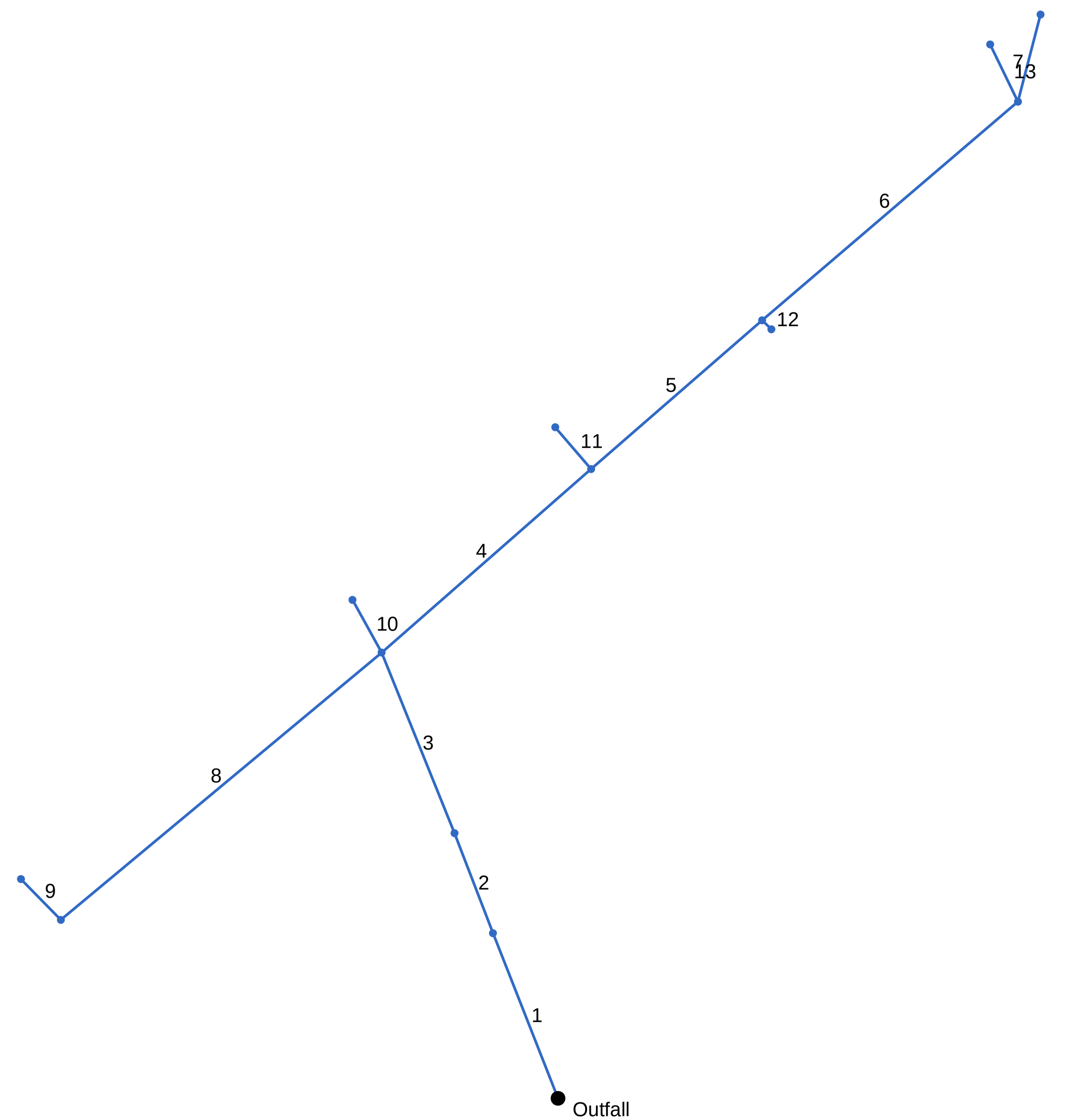
Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Dn	Up	Dn	Up	Dn	Up	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	44.000	0.00	2.59	0.00	0.00	1.17	0.0	26.3	4.3	5.03	17.49	4.42	18	2.77	-0.98	0.24	0.02	1.10	0.52	3.39	
2	1	190.000	1.31	2.59	0.45	0.59	1.17	14.0	25.2	4.4	5.14	2.81	4.19	15	0.19	0.24	0.60	1.61	2.81	3.39	3.34	
3	2	41.000	1.28	1.28	0.45	0.58	0.58	25.0	25.0	4.4	2.55	3.91	2.08	15	0.37	0.53	0.68	2.85	2.92	3.34	3.28	

Project File: System_Creek_Terrace.stm | Number of lines: 3 | Run Date: 01-28-2011

NOTES: Intensity = 56.41 / (Inlet time + 9.25) ^ 0.72; Return period = 10 Yrs. ; c = cir e = ellip b = box

Hydraflow Storm Sewers Extension for AutoCAD® Civil 3D® 2008 Plan



Project File: System_Willard_Existing.stm	Number of lines: 13	Date: 01-28-2011

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr line No.	Line length (ft)	Defl angle (deg)	Junc type	Known Q (cfs)	Drng area (ac)	Runoff coeff (C)	Inlet time (min)	Invert El Dn (ft)	Line slope (%)	Invert El Up (ft)	Line size (in)	Line shape	N value (n)	J-loss coeff (K)	Inlet/ Rim El (ft)	
1	End	134.000	-111.324	MH	0.00	0.57	0.30	14.0	-1.27	0.73	-0.29	36x48	Box	0.013	0.15	4.19	
2	1	81.000	-0.194	MH	0.00	1.39	0.30	28.0	-1.29	0.21	-1.12	24x36	Box	0.013	0.15	3.70	
3	2	147.000	-0.427	MH	0.00	1.31	0.45	14.0	-1.12	0.37	-0.57	24x36	Box	0.013	1.00	3.62	
4	3	210.000	70.716	MH	0.00	0.42	0.45	13.0	0.43	0.48	1.44	18	Cir	0.013	1.00	4.06	
5	4	171.000	0.194	MH	0.00	1.39	0.45	28.0	1.51	0.50	2.36	18	Cir	0.013	0.99	4.70	
6	5	254.000	0.471	MH	0.00	0.00	0.00	0.0	2.48	0.91	4.80	18	Cir	0.013	0.97	7.78	
7	6	68.000	-34.211	MH	9.79	2.93	0.45	25.0	4.74	1.50	5.76	15	Cir	0.013	1.00	8.52	
8	3	315.000	-107.885	MH	0.00	0.05	0.45	5.0	0.43	0.22	1.11	18	Cir	0.013	1.00	3.81	
9	8	43.000	85.239	MH	0.00	1.89	0.45	23.0	1.11	1.21	1.63	15	Cir	0.013	1.00	4.41	
10	3	45.000	-6.127	MH	0.00	7.90	0.45	34.0	0.43	0.29	0.56	24x36	Box	0.013	1.00	3.61	
11	4	41.000	-88.419	MH	0.00	3.09	0.45	25.0	1.44	0.68	1.72	15	Cir	0.013	1.00	4.34	
12	5	10.000	83.158	MH	0.00	0.85	0.45	24.0	3.58	-0.50	3.53	8	Cir	0.013	1.00	4.37	
13	6	48.000	-75.312	MH	0.00	2.24	0.45	31.0	4.79	2.33	5.91	15	Cir	0.013	1.00	8.54	

Project File: System_Willard_Existing.stm | Number of lines: 13 | Date: 01-28-2011

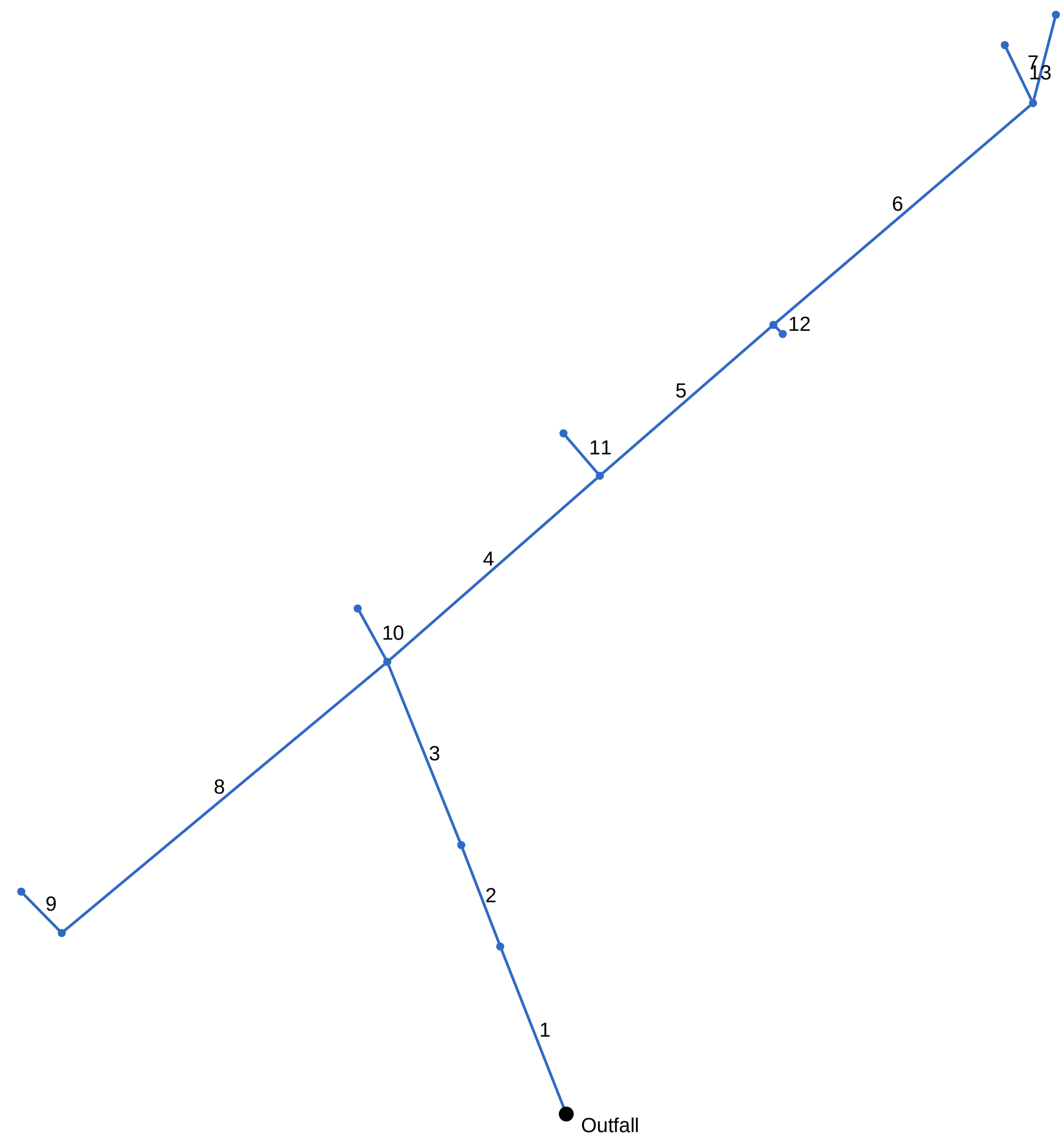
Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Dn	Up	Dn	Up	Dn	Up	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	134.000	0.57	24.03	0.30	0.17	10.52	14.0	34.9	3.4	45.83	105.8	6.45	36 x 48 b	0.73	-1.27	-0.29	0.73	1.31	0.00	4.19	
2	1	81.000	1.39	23.46	0.30	0.42	10.35	28.0	34.7	3.4	45.35	22.35	7.56	24 x 36 b	0.21	-1.29	-1.12	2.59	3.29	4.19	3.70	
3	2	147.000	1.31	22.07	0.45	0.59	9.93	14.0	34.4	3.5	44.11	29.84	7.35	24 x 36 b	0.37	-1.12	-0.57	3.42	4.62	3.70	3.62	
4	3	210.000	0.42	10.92	0.45	0.19	4.91	13.0	31.9	3.6	27.50	7.28	15.56	18	0.48	0.43	1.44	5.46	19.87	3.62	4.06	
5	4	171.000	1.39	7.41	0.45	0.63	3.33	28.0	31.7	3.6	21.86	7.40	12.37	18	0.50	1.51	2.36	23.64	31.05	4.06	4.70	
6	5	254.000	0.00	5.17	0.00	0.00	2.33	0.0	31.3	3.6	18.27	10.04	10.34	18	0.91	2.48	4.80	33.40	41.10	4.70	7.78	
7	6	68.000	2.93	2.93	0.45	1.32	1.32	25.0	25.0	4.1	15.22	7.91	12.40	15	1.50	4.74	5.76	42.71	46.49	7.78	8.52	
8	3	315.000	0.05	1.94	0.45	0.02	0.87	5.0	23.2	4.3	3.74	4.88	2.11	18	0.22	0.43	1.11	5.46	5.86	3.62	3.81	
9	8	43.000	1.89	1.89	0.45	0.85	0.85	23.0	23.0	4.3	3.66	7.10	2.98	15	1.21	1.11	1.63	5.93	6.07	3.81	4.41	
10	3	45.000	7.90	7.90	0.45	3.56	3.56	34.0	34.0	3.5	12.36	26.22	2.06	24 x 36 b	0.29	0.43	0.56	5.46	5.49	3.62	3.61	
11	4	41.000	3.09	3.09	0.45	1.39	1.39	25.0	25.0	4.1	5.73	5.34	4.67	15	0.68	1.44	1.72	23.64	23.96	4.06	4.34	
12	5	10.000	0.85	0.85	0.45	0.38	0.38	24.0	24.0	4.2	1.61	0.00	4.61	8	-0.50	3.58	3.53	33.40	33.58	4.70	4.37	
13	6	48.000	2.24	2.24	0.45	1.01	1.01	31.0	31.0	3.7	3.69	9.86	3.01	15	2.33	4.79	5.91	42.71	42.87	7.78	8.54	

Project File: System_Willard_Existing.stm | Number of lines: 13 | Run Date: 01-28-2011

NOTES: Intensity = 57.19 / (Inlet time + 10.00) ^ 0.74; Return period = 10 Yrs. ; c = cir e = ellip b = box

Hydraflow Storm Sewers Extension for AutoCAD® Civil 3D® 2008 Plan



Project File: System_Willard_Proposed.stm	Number of lines: 13	Date: 01-28-2011

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr line No.	Line length (ft)	Defl angle (deg)	Junc type	Known Q (cfs)	Drng area (ac)	Runoff coeff (C)	Inlet time (min)	Invert El Dn (ft)	Line slope (%)	Invert El Up (ft)	Line size (in)	Line shape	N value (n)	J-loss coeff (K)	Inlet/ Rim El (ft)	
1	End	134.000	-111.324	MH	0.00	0.57	0.30	14.0	-1.27	0.14	-1.08	36x48	Box	0.013	0.15	4.19	
2	1	81.000	-0.194	MH	0.00	1.39	0.30	28.0	-1.08	0.14	-0.97	36x48	Box	0.013	0.15	3.70	
3	2	147.000	-0.427	MH	0.00	1.31	0.45	14.0	-0.97	0.13	-0.78	36x48	Box	0.013	1.00	3.62	
4	3	210.000	70.716	MH	0.00	0.42	0.45	13.0	-0.78	0.45	0.16	30	Cir	0.013	1.00	4.06	
5	4	171.000	0.194	MH	0.00	1.39	0.45	28.0	0.16	0.29	0.65	30	Cir	0.013	0.99	4.70	
6	5	254.000	0.471	MH	0.00	0.00	0.00	0.0	0.65	0.70	2.44	24	Cir	0.013	0.97	7.78	
7	6	68.000	-34.211	MH	9.79	2.93	0.45	25.0	2.44	2.24	3.96	24	Cir	0.013	1.00	8.52	
8	3	315.000	-107.885	MH	0.00	0.05	0.45	5.0	0.43	0.22	1.11	18	Cir	0.013	1.00	3.81	
9	8	43.000	85.239	MH	0.00	1.89	0.45	23.0	1.11	1.21	1.63	15	Cir	0.013	1.00	4.41	
10	3	45.000	-6.127	MH	0.00	7.90	0.45	34.0	0.43	0.29	0.56	24x36	Box	0.013	1.00	3.61	
11	4	41.000	-88.419	MH	0.00	3.09	0.45	25.0	0.14	3.85	1.72	15	Cir	0.013	1.00	4.34	
12	5	10.000	83.158	MH	0.00	0.85	0.45	24.0	3.18	3.50	3.53	8	Cir	0.013	1.00	4.37	
13	6	48.000	-75.312	MH	0.00	2.24	0.45	31.0	2.44	7.23	5.91	15	Cir	0.013	1.00	8.54	

Project File: System_Willard_Proposed.stm | Number of lines: 13 | Date: 01-28-2011

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	134.000	0.57	24.03	0.30	0.17	10.52	14.0	35.4	3.4	45.53	46.60	5.44	36 x 48 b	0.14	-1.27	-1.08	0.73	1.11	0.00	4.19	
2	1	81.000	1.39	23.46	0.30	0.42	10.35	28.0	35.0	3.4	45.16	45.61	4.51	36 x 48 b	0.14	-1.08	-0.97	1.42	1.53	4.19	3.70	
3	2	147.000	1.31	22.07	0.45	0.59	9.93	14.0	34.4	3.5	44.11	44.50	4.33	36 x 48 b	0.13	-0.97	-0.78	1.58	1.76	3.70	3.62	
4	3	210.000	0.42	10.92	0.45	0.19	4.91	13.0	32.6	3.6	27.28	27.44	5.56	30	0.45	-0.78	0.16	2.05	2.98	3.62	4.06	
5	4	171.000	1.39	7.41	0.45	0.63	3.33	28.0	32.0	3.6	21.79	21.95	4.44	30	0.29	0.16	0.65	3.46	3.94	4.06	4.70	
6	5	254.000	0.00	5.17	0.00	0.00	2.33	0.0	31.3	3.6	18.27	18.99	5.82	24	0.70	0.65	2.44	4.25	5.91	4.70	7.78	
7	6	68.000	2.93	2.93	0.45	1.32	1.32	25.0	25.0	4.1	15.22	33.82	4.85	24	2.24	2.44	3.96	6.42	6.72	7.78	8.52	
8	3	315.000	0.05	1.94	0.45	0.02	0.87	5.0	23.2	4.3	3.74	4.88	2.20	18	0.22	0.43	1.11	2.05	2.42	3.62	3.81	
9	8	43.000	1.89	1.89	0.45	0.85	0.85	23.0	23.0	4.3	3.66	7.10	3.31	15	1.21	1.11	1.63	2.50	2.58	3.81	4.41	
10	3	45.000	7.90	7.90	0.45	3.56	3.56	34.0	34.0	3.5	12.36	26.22	2.63	24 x 36 b	0.29	0.43	0.56	2.05	2.07	3.62	3.61	
11	4	41.000	3.09	3.09	0.45	1.39	1.39	25.0	25.0	4.1	5.73	12.68	4.67	15	3.85	0.14	1.72	3.46	3.78	4.06	4.34	
12	5	10.000	0.85	0.85	0.45	0.38	0.38	24.0	24.0	4.2	1.61	2.26	4.61	8	3.50	3.18	3.53	4.25	4.43	4.70	4.37	
13	6	48.000	2.24	2.24	0.45	1.01	1.01	31.0	31.0	3.7	3.69	17.36	3.84	15	7.23	2.44	5.91	6.42	6.68	7.78	8.54	

Project File: System_Willard_Proposed.stm | Number of lines: 13 | Run Date: 01-28-2011

NOTES: Intensity = 57.19 / (Inlet time + 10.00) ^ 0.74; Return period = 10 Yrs. ; c = cir e = ellip b = box

Appendix C

Site Photos

Looking Down S. Willard Avenue from Intersection of Mill Creek Terrace toward E. Howard Street

Looking Down Mill Creek Terrace from S. Willard Avenue

Looking from 12 Mill Creek Terrace toward Cul-de-sac

Looking from 14 Mill Creek Terrace toward Cul-de-sac. Note Curb Drop Inlet on Left

Mill Creek Terrace Cul-de-sac, Looking Toward Wanchese Property

Mill Creek Terrace Curb Drop Inlet on Outfall #1 between 18 and 14 Mill Creek Terrace

Looking from Cul-de-sac toward 10 Mill Creek Terrace

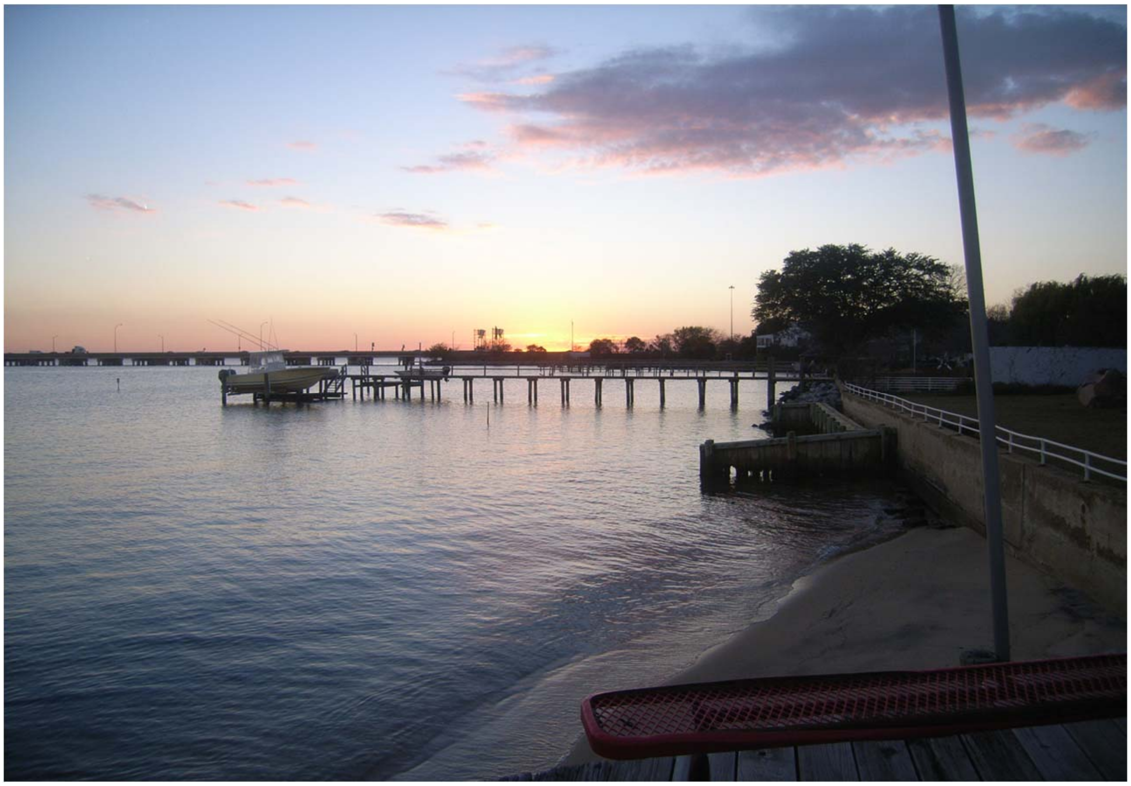
Looking from 9 Mill Creek Terrace toward S. Willard Avenue

Looking at the back Property of 14 Mill Creek Terrace, Near Outfall #1

Looking at the back Property of 18 Mill Creek Terrace near Outfall #1

Behind 18 Mill Creek Terrace, Looking Toward Wanchese Fish Company Docks

Outfall #1 Behind 18 Mill Creek Terrace



Looking Southwest Along Sea Wall behind 14 Mill Creek Terrace

S. Willard Avenue Lookingin front of 321 Looking Toward the VDOT Maintenance Facility

310 S. Willard Avenue. Note Curb Drop Inlet

Outfall #2 Curb Drop Inlet in front of 321 S. Willard Avenue. Note Tidal Water in the Box

Driveway at 321 S. Willard Avenue-General Route of Outfall #2

S. Willard Avenue Looking from 331 Toward Mill Creek Terrace

Vacant Lot at 313 S. Willard Avenue Alongside Mill Creek Terrace Subdivision(Possible New Outfall Route)

Vacant Lot 313 S. Willard Avenue, behind 6 Mill Creek Terrace

Vacant Lot at 313 S. Willard Avenue, behind 10 Mill Creek Terrace

End of Seawall behind 12 Mill Creek Terrace

Corner of Seawall behind 12 Mill Creek Terrace

Looking South Along Shoreline from 313 S. Willard Avenue, Toward Outfall #2

Looking North West Along Shoreline of 313 S. Willard Avenue

Wanchese Fish Company Parking Lot Looking Toward Mill Creek

Wanchese Fish Company Looking Down Paved Ditch Along Property Line of 20 Mill Creek Terrace

Wanchese Fish Co. Looking Down Paved Ditch. Note Low Retaining Wall and Drain Pipe (Mill Creek Behind Wall)

Wanchese Fish Company Looking toward Docks from Area of Low Wall

Wanchese Fish Company Looking From Docks toward Parking Lot

Appendix D

Tide Gate Information

Tideflex Technologies
600 N. Bell Ave., Carnegie, PA 15106
Phone: 412.279.0044
Fax: 412.279.7878

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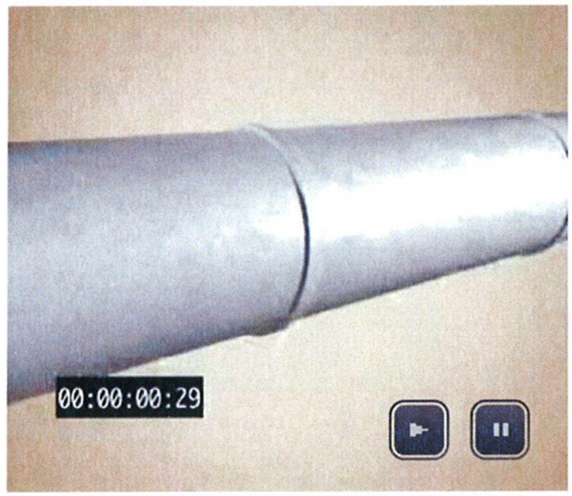
Your Winning Solution For Backflow Prevention and Odor Mitigation

Features

- Extremely low headloss
- Durable 100% elastomer construction
- Easily installed in any type of pipe
- No menchanical parts
- 4" (100 mm) - 72" (1800 mm) size
- 25 year life expectancy
- Operates on differential pressure
- Virtually maintenance-free
- Self-draining
- Less than 1" of head pressure cracks open valve
- Eliminates standing water
- Silent, non-slamming
- Simple installation
- Extensive independent hydraulic testing
- Opens to near full pipe diameter

Materials Of Construction

Elastomer Information
Expansion Clamps:
304 Stainless Steel (Standard)
316 Stainless Steel
Special Alloys Available



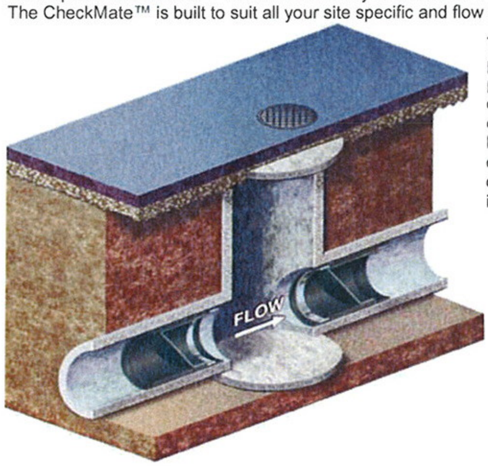
To view the CheckMate Valve in action, press the play button above.

Description

Patented by Red Valve Company, the CheckMate™ Inline Check Valve is ideal for backflow prevention and odor mitigation. In outfalls, stormwater, CSO and SSO applications, the CheckMate's™ custom-engineered, all-rubber unibody design eliminates costly backflow from oceans, rivers and interceptors. CheckMate™ Valves are readily available in 4" to 72" sizes. The CheckMate™ is built to suit all your site specific and flow needs.

CheckMate Brochure

Request Info/Contact Us



The CheckMate's™ unique elastomer-reinforced design provides a proven record of maintenance-free performance, cost savings and results that no other inline check valve can match. The valve has a 100% fabric and elastomer construction that eliminates corrosion problems. Because the CheckMate™ is made with a unibody construction, there are no mechanical components to catch debris, corrode or fail. The result is in savings - both in time and costs.

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Flap Gate / Tide Gate Alternatives

This document lists many of the available alternatives for flap gates and tide gates. It also includes my opinions and observations regarding the pros and cons of each design. If you are aware of some other flap gate / tide gate alternatives, or if you have comments regarding anything in this document, please e-mail me at Jeff.Juel@Jueltide.com. I will modify and expand this document periodically.

Top Hinged Flap Gates

Photo 1- Cast iron or ductile iron flap gate by Hydro Gate

Top hinged flap gates have been in use at tide gates for centuries. Top hinged flap gates are typically made from wood, cast iron, steel, aluminum, FRP (fiber reinforced polymer), or fiberglass. Designs are produced by a number of manufacturers. I have seen or worked on numerous top-hinged flap gates including some made of treated timbers with weights attached that simply hang on heavy chains (see photo below).

Light weight varieties of top hinged flap gates have less head loss and allow upstream fish passage under some flow conditions. None of the top hinged flap gate designs allow backflow unless they leak or are tied or propped open.

The photo to the right shows one of three very large timber flap gates as it is being removed from the Highway 101 bridge where it crosses the Chinook River near Ilwaco Washington.

Photo 2 - Large timber flap gate

Pros:

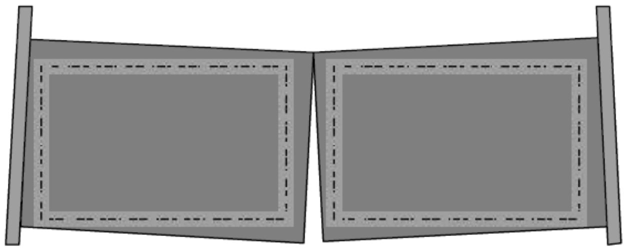
- Very simple operation.
- Reasonably durable and reliable.
- Prevents salt water intrusion.

Cons:

- Does not allow tidal flushing. This dramatically degrades the water quality of upstream watercourse and also causes sedimentation in the flow channel.
- If water-tight or nearly water-tight, a flap gate dramatically lowers the surface water and ground water levels upstream[1]. During dry periods, if there is any surface water upstream from a flap gate, it will typically be stagnant with low dissolved oxygen and poor water quality. Dry & hot weather will result in significantly elevated water temperatures.
- Top hinged flap gates don't pass floating debris easily. Debris may have to be manually removed periodically.
- Heavier gates don't open very wide. This results in significant head loss at the flap gate which reduces the conveyance capacity of the outlet.
- Fish have difficulty passing heavy flap gates since they are normally either closed or only barely cracked open with high velocity flow passing through a small opening.
- Aluminum flap gates have been reported stolen and presumably sold for scrap.
- If mixed metals are used, sacrificial anodes are required. Sacrificial anodes have to be inspected and replaced periodically.
- The hinge mechanism will eventually wear out with time.
- If the flap gate closes on debris and then experiences a large seating head, the wracking forces can damage the flap gate and/or hinges.

[1] Wetlands located upstream from flap gates are effectively dewatered during dry periods.

Side Hinged Tide Gates



Sketch 1 – Side Hinged Tide Gates

Large, side hinged tide gates are angled inward, providing a small closing force, and are typically mounted over large, rectangular culverts.[2]

Pros:

- Very simple operation.
- Reasonably durable and reliable.
- Opens wide with little flow - allowing fish passage during outflow.
- Does not collect floating debris.

Cons:

- Does not allow tidal flushing (unless lashed or propped open).[3]
- Fairly large forces are imposed on the hinge mechanism due to the cantilevered gate leaves.

Tide Flex Valve by RedValve

Photo 1 - Tide Flex Series TF-2 Check Valve

Tide Flex valves are also known as a "duckbill style check valve". The valve is attached to the downstream (tidal) end of a culvert. The check valve is made of a flexible synthetic material that deforms to provide an opening in the duckbill when there is a higher water level on the upstream end of the culvert.

Pros:

- Extremely simple operation
- Very durable and reliable

Cons:

- The device is virtually water-tight and does not allow any backflow for tidal flushing.
- The tide flex valve does not open very wide under low flow and only passes very small floating debris. Accumulated debris may have to be removed periodically. Manual removal of debris is very difficult.
- Rodents (muskrats) have been reported to chew on the tide gate.[4]
- Head loss at this type of valve may be unacceptable.[5]

---

[2] From Tide Gate Modifications for Fish Passage and Water Quality Enhancement – Tillamook Bay National Estuary Project by Jay Charland, August 27, 1998.

[3] Someone must release the gates prior to floods or high water. If the tide gates remain lashed open during a flood, there will be liability issues.

[4] Personal communication with Shawn Shotzberger, AKRF Senior Environmental Scientist, November 2009.

[5] If you would like a Tide Flex valve, I have a contact with the City of Aberdeen who would love to sell a couple of Tide Flex valves that are like new and have been in storage for years. They were installed and then removed because they had excessive head loss and were nearly impossible to keep free of debris.

Sluice Gate with Electric Operator

<no photo available at this time[6]>

A motorized vertical lift slide gate or sluice gate is probably the most obvious alternative for a water control device that can be used to allow tidal flushing while preventing flooding during extreme tides. A number of suppliers are capable of providing a motorized sluice gate. A Program Logic Controller (PLC) can be programmed to operate the electric motor which raises and lowers the sluice gate. Limit switches detect when the gate is in the fully open or fully closed position. Intermediate gate positions are detected via a rheostat or some other device. Sensors monitor the water levels upstream and downstream from the sluice gate and provide input to the PCL. The PLC directs the electric motor to raise or lower the sluice gate according to the logic programmed in the PCL. The sluice gate can be fully open, fully closed, or partially open at any time depending on the water levels upstream and downstream of the sluice gate and the programming of the PCL.

There will be two operating modes with separate control schedules to address normal conditions and storm conditions. During normal operations, the gate will programmed to remain open until water levels reach a set elevation for a defined length of time, at which point it will close. In effect, natural tidal fluctuations will occur unless action is needed to prevent flooding of upstream properties.[7]

This alternative requires electric service at the tide gate.

Pros:

- The operation of the sluice gate (via the programming of the PCL) can be very sophisticated and can be modified over time if needed.
- The sluice gate can be used to impound water upstream[8].

Cons:

- Relatively complicated. [9]
- Relatively expensive.
- Requires reliable electrical service at the tide gate site and/or a power monitoring system with alarms and/or a backup power system.
- Requires a maintenance person capable of operating and programming the PCL.
- This device is not particularly fail-safe. Power outages, motor breakdowns, PCL programming errors, etc can result in the sluice gate being open when it should be closed and vice versa.
- Someone will be responsible to pay a monthly electric bill.

[6] This alternative is currently being considered for a project that is under design by Vine Associates. I am not aware of any existing tide gates that utilize this design. Similar systems are used in sewage treatment plants.
[7] E-mail correspondence from Gregory Robbins, Vine Associates, December 2009.
[8] This will reduce tidal flushing and negatively affect water quality. It will also preclude fish passage during part of the tide cycle.
[9] The PLC and motor control device is normally provided by a different supplier than the motorized sluice gate.

Waterman / Nekton Self-Regulating Tide Gate

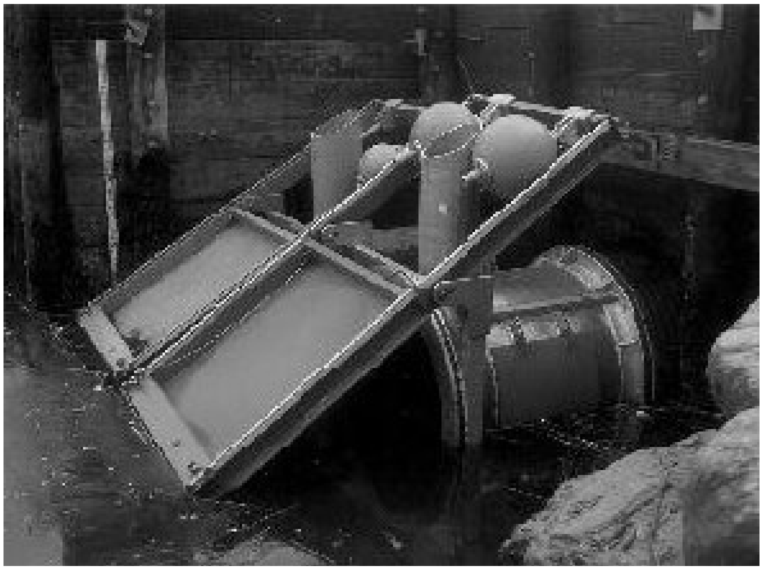


Photo 2- Self Regulating Tide Gate by Waterman Industries

This is the original “Self Regulating Tide Gate” (or “SRT”) produced by Waterman Industries. The flap gate is top-hinged and uses a buoyant plate (the “lid”) along with floats which are secured to the frame above the culvert. The position of the floats controls when the tide gate closes on a rising tide. The buoyant tide gate lid floats opens with the rising tide. As the water level continues to rise, at some point the floats above the culverts become submerged and their buoyancy forces the lid to close, stopping the backflow through the culvert. For the configuration shown in the photo above, the “trip elevation” (the water level at which the gates close) must be higher than the top of the culverts. The culverts are vented to prevent water hammer when the lid slams shut during pipe-full flow.

Pros:

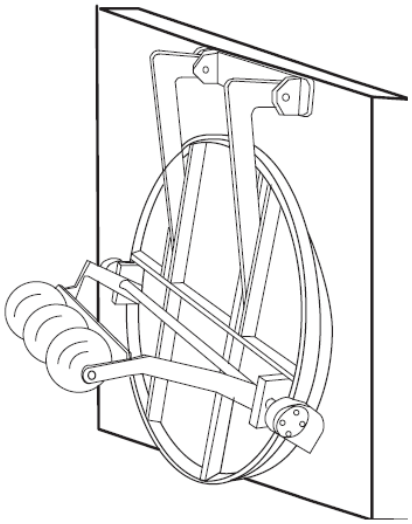
- Relatively simple operation.
- Floating debris is usually swept from the gate by high flows.
- Allows substantial volumes of tidal flushing.

Cons:

- Floating debris can get tangled in the frame above the culvert and interfere with the operation of the flap gate.
- Adjusting the floats to change the elevation at which the gate closes is difficult and limited to a small range.
- This type of flap gate can slam shut[10]. If the pipe can be flowing full when the gate closes, a vertical vent should be installed in the culvert behind the SRT to prevent a high pressure shock wave caused by water hammer. After the gate slams shut, surges can cause the gate to open and close several times.
- During very high water levels, the submerged vent tubes will pass flood water upstream.
- A Waterman SRT was installed at Edison Slough in Skagit County WA around 2003. It could not be made to operate properly and was removed in 2006.

[10] I have never watched this type of tide gate in operation. I suspect that it always slams shut. The associated noise may be unacceptable if the tide gate is located in a populated area and closes with regularity.

Mitigator Fish Passage Device, by Nehalem Marine / Leo Kuntz



What makes this tide gate different from other traditional top-hinged tide gates is the Mitigator Fish-Passage Device that is attached to the tide gate. The Mitigator Fish-Passage Device is a float-operated, cam-lock system that prevents a portion of the tide gate from closing during the lower part of the flood tide. [11]

Pros:

- Allows some tidal flushing.

Cons:

- Only opens to 20 degrees when the gate first opens.
- Moderately complicated.
- Floating debris can damage or interfere with the operation of the floats.
- Adjusting the floats to change the elevation at which the gate closes is difficult.
- Only a fraction of the culvert diameter is open on the rising tide.

Muted Tide Regulator, by Nehalem Marine / Leo Kuntz

<no photo available at this time>

This is a side-hinged flap gate with a mechanism that prevents the gate from closing until a float is raised by the rising tide. The float is located on the protected side of the tide gate and the device can be designed to accommodate adjustments in the float setting.

Pros:

- Allows tidal flushing.
- Very heavy-duty high quality fabrication.

Cons:

- This type of tide gate is relatively expensive.
- The control mechanism is fairly complicated.
- The float can be very large. At Fisher Slough in Skagit County, it's the size of a small economy car.
- The design is not inherently fail-safe. If the float fails to rise for some reason, the gates will be held open and flooding will occur.

[11] From Tide Gates in the Pacific Northwest - Operation, Types, and Environmental Effects by Guillermo Giannico and Jon A. Souder.

Armtec Side Opening Flap Gate

Photo 3 - Side Opening Flap Gate at Nanaimo BC

The photo to the left is a side hinged flap gate installed at Namaimo BC. The tide gate was installed with a torsion spring on the hinge. The spring was initially installed and tensioned “for closure assistance”. As an afterthought, the spring was tensioned to hold the tide gate open - thereby allowing some backflow. The spring began corroding badly and in 2009 the spring was replaced with a very expensive stainless steel spring.

Pros:

- Allows some tidal flushing
- Minimal head loss during outflow

Cons:

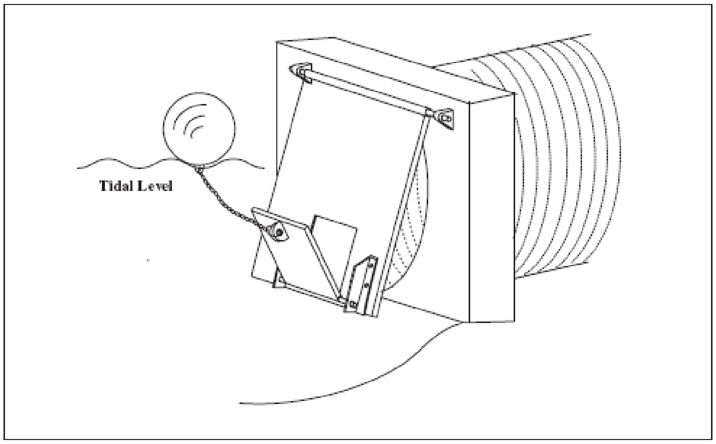
- Mixed metals in salt water - the gate was fabricated using 304 stainless steel and aluminum. If the insulated connectors fail, severe corrosion will occur.
- 304 stainless steel is not the best grade of stainless steel for salt water exposure. 316 stainless steel is a superior choice.
- The gate doesn’t open very wide.
- The stiffness of the spring is not adjustable.

Tide Gates Produced By Golden Harvest

Kevin Buchanan, the owner of Golden Harvest, boasts that with his collection of tide gate designs, he is "like a paint store selling several colors of paint".[12] In my opinion, the various designs are simply a parade of Golden Harvest's multiple attempts to produce, copy, or steal a viable self regulating tide gate design. But you can be the judge.

The following tide gates are or have been produced by Golden Harvest:

Bottom-Hinged Pet Door



On a rising tide, the large flap gate is closed and the smaller gate – the "pet door" – closes when the water level is high enough to float the ball on the chain. [13] This design is the brain-child of OSU graduate student Jay Charland[14]

Pros:

- Probably would be relatively inexpensive.
- Very simple operation.
- Fish can pass through the "pet door" - until it gets plugged with debris.
- Allows some tidal flushing - until the "pet door" gets plugged with debris.

Cons:

- The "pet door" tends to get plugged with debris.
- The "pet door" is too small to allow much tidal flushing and flow velocities through the pet door are very high most of the time.
- It will not work in many locations.[15]
- Golden Harvest produced this device for the Tillamook Bay area, but it appears that they no longer actively sell this device since it is not mentioned in their on-line tide gate catalog.

[12] Personal Conversation, June 2008.
[13] The Effects of Tide Gates on Estuarine Habitats and Migratory Fish by Guillermo R. Giannico and Jon A. Souder
[14] OSU Develops Fish Friendly Tide Gate (2/18/98) http://oregonstate.edu/dept/ncs/newsarch/1998/Feb98/tidegate.htm
[15] Top-hinged tide gates with bottom-hinged pet doors have been installed in Tillamook Bay, Oregon (Charland 1997). However, as in the case of the tide gates with top hinged pet doors in Tillamook Bay, the gates with bottom hinged pet doors failed and were replaced with traditional top-hinged tide gates.

Golden Harvest GH-52SC Combination Gate

Photo 4 - Combination Gates were installed to replace existing timber flap gates on Highway 101 Bridge crossing Chinook River.

This tide gate is essentially a top-hinged flap gate mounted on a frame with a mechanical lift that allows the flap gate to be raised or lowered. When completely lowered, this is simply a top hinged flap gate that allows no backflow.

When partially raised, the flap gate allows some backflow during rising tides. The backflow passes beneath the bottom edge of the partially raised flap gate.

When fully raised, the flap gate is completely above the opening and full tidal exchange is allowed.

Pros:

- The aluminum flap gate is very light weight and opens wide under moderate flow.
- Simple operation.

Cons:

- At present, backflow is only allowed during summer months.[16]
- The flap gate does not automatically close during high water levels with high backflow.
- When partially (or fully) raised, the amount of backflow and the upstream water level will vary dramatically with variations in the tide levels downstream. Extreme high tides will result in very high backflow rates and higher water levels upstream.
- Floating and water-logged debris could hang up on the partially raised flap gate during a rising tide.
- The flap gate must be manually raised and lowered.
- Raising and lowering the gate is labor-intensive and requires a large hydraulic power operator on a trailer.
- Sacrificial anodes must be checked and replaced periodically.

[16] Personal communication with Kyle Guzlas, Washington Dept. of Fish & Wildlife, December 2009.

Golden Harvest Model GH-35

Photos 5 & 6- Golden Harvest Model GH-35

This tide gate is identical to the Waterman SRT[17]. Golden Harvest has been telling people that they purchased the rights to this design from Waterman Industries around 2004[18]. The photo above on the left was copied from Golden Harvest's on-line tide gate catalog. This particular tide gate is actually an SRT fabricated by Waterman Industries and delivered to Skagit County in 1998.[19]

In the photos above, the floats have been removed from the attachment points on the frame above the culvert and instead are attached to arms extending behind/down and alongside the end of the culvert. The reason for revising the location of the floats was to cause the tide gate to close earlier during a rising tide. The tide gate did not function properly and repeatedly flooded the upstream property owner. In 2006 (after this photo was taken), Skagit County let a contract to remove the GH-35 and replace it with a regular top-hinged flap gate. A Golden Harvest model GH-850 (see the photo on page 11) was installed on the culvert to the right of this culvert. It also failed to operate properly.

Pros:

- Same as for the Waterman SRT.
- Should be competitively priced. If you are interested in this tide gate alternative, be sure to also get a price from Waterman Industries at (800) 331-0808.

Cons:

- Same as for the Waterman SRT
- Golden Harvest was not able to get this design to work properly at Edison Slough.[20] At this site (located in the town of Edison in Skagit County Washington), the upstream property owner reports that he observed the tide gate slam shut and then pop open 21 times on a single tide. This particular flap gate flooded the upstream property several times.[21] The tide gate was eventually removed and a Golden Harvest Model GH-850 was installed. (See page 11.)

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[17] If you compare Golden Harvest's on-line tide gate catalog http://www.goldenharvestinc.com/pdfs/catalogs/tide_gate_cat.pdf to Waterman Industries' documentation on their Self Regulating Tide Gate http://watermanusa.com/PDF/SRT.pdf it is obvious that Golden Harvest not only copied Waterman Industries' tide gate design, they also plagiarized much of the documentation.

[18] *"…it is my understanding that the Golden Harvest Company bought out Waterman Industries about 6 to 8 years ago, including Waterman's patents and marketing material."* - E-mail from Tom Slocum (Washington Conservation Districts Northwest Region Engineer) to Jeff Juel dated December 8, 2009. In an e-mail dated December 8, 2009, the CEO of Waterman Industries informed me (Jeff Juel) that this is patently false.

[19] E-mail from Waterman Industries CEO dated 22 December 2009.

[20] In spite of this particular tide gate not being theirs, not working properly, and ultimately being removed, Golden Harvest uses a photo of this tide gate in their on-line Tide Gate Catalog.

[21] Personal communication with Mr. Duane Eitriem, January 2009.

Golden Harvest Model GH-37

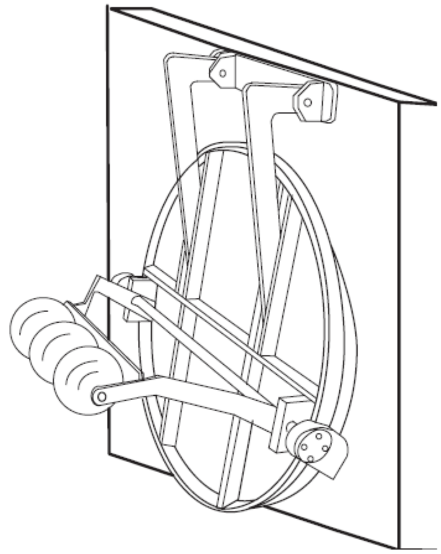

Photo 6 – Golden Harvest Model GH-37 at Beaufort SC

The photo above is from Golden Harvest's on-line tide gate catalog. This tide gate is not identical, but is operationally similar to the Mitigator Fish Passage device produced by Leo Kuntz - which is shown to the right of the photo[22]. In both designs, the floats activate a cam that allows the lower half of the tide gate to close when the floats are lifted by the rising tide

I do not have first-hand knowledge regarding the operation of this type of tide gate. In the photo above, the gate appears to be closed– or just barely cracked open. It could not possibly allow very much backflow in this configuration.

I presume that the pros and cons that apply to the Mitigator Fish Passage Device (produced by Leo Kuntz) also apply to the Golden Harvest Model GH-37.

[22] In November 2009, I met Leo Kuntz and I asked him about the similarities between his tide gate design and the Golden Harvest GH-37. He replied that he was aware of Golden Harvest and "their" tide gates, but he didn't pay too much attention to them. He felt that Golden Harvest has difficulties producing working self regulating tide gates - so they are actually not much of a threat. He told me that he just ignores them.

Golden Harvest Model GH-850-R

Photo 7 - Golden Harvest Model GH-850 at Edison Slough

The photo to the left is at Edison Slough, Skagit County WA. The photo is also from Golden Harvest's on-line tide gate catalog. The culvert in the bottom left corner of this photo (only the tops of the hinges are showing) is the culvert that used to have the Golden Harvest model GH-35 flap gate. (See page 9.) It was removed[23] and replaced with a normal top-hinged flap gate when the model GH-850-R was installed[24].

At this particular site, the tide gate was nearly always closed.[25] In fact it is closed in this photo. The photo was taken when the tide was falling and the water level is well below the high tide level - so it should be open. Golden Harvest has a working copy of their GH-850 at McElroy Slough, so their model GH-850 (my Aberdeen design) can be made to work – at least at some locations.

Pros:

- Works reliably in some locations and allows tidal flushing.
- Montesnano Office Fish and Wildlife Manager Bob Burkle (back in 1996) said: "I've never seen a tide gate as good."[26]

Cons:

- Very complicated[27] and not completely fail-safe. In 1995 when I explained how my proposed tide gate design would work to Aberdeen's City Engineer Ron Merilla, he quipped: "It's kind of Rube Goldberg, but I can't see why it wouldn't work." It does work, but it is overly complicated compared to the VBFG™ system.
- This is an overly expensive knock-off.28 If you are interested in this tide gate alternative, be sure to get a price from Juel Tide Gates at (206) 300-4204.
- Requires sufficient outflow for the gate to open fully – otherwise "Tide Gate Entropy Death" may occur.
- Golden Harvest did not succeed in getting this design to work – at least at Edison Slough. In January 2009, this tide gate was retrofitted with a VBFGTM control mechanism by Juel Tide Gates. It's been working flawlessly since then[29].

For comparison, to the left is a photo of the Aberdeen Tide Gate designed by Jeff Juel in 1995. Juel Tide Gates can provide this design with the hydraulic control mechanism - however it costs more and has no advantages over an identical side-hinged flap gate using the new VBFG™ control mechanism.

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[23] The winning bidder's cost for removal and disposal of the malfunctioning model GH-35 was $10,000.
[24] The winning bidder's cost for the new (and dysfunctional) model GH-850 was $62,000.
[25] Personal Communication with Duane Eitriem, the property owner located just upstream at Edison Slough.
[26] Quote from article about South Aberdeen and Cosmopolis Flood Control Project in 1996.
[27] The hydraulic control mechanism includes a large number of components: hydraulic cylinder, hoses, directional control valve, pressure-compensating flow control valve, check valves, and a hand pump.
[28] On a large tide gate project bid in June 2009, the fabricator of the Aberdeen design submitted a bid to supply the original tide gates as an equal. Their bid was 33% less than the bid submitted by Golden Harvest.
[29] Personal Communication with Duane Eitriem, November 2009.

Variable Backflow Flap Gate (VBFG™) by Juel Tide Gates

The patent pending VBFG™ tide gate is a side-hinged flap gate[30] that is controlled by tension in rigging that is continually pulling the tide gate open. During a rising tide, the backflow through the culvert generates a "draft force" drawing the gate closed. This draft force is resisted by the tension in the rigging. The draft force grows at an increasing rate with the rising tide due to: 1) the growing area of the submerged portion of the gate leaf – "the sail"; 2) the increasing flow velocity due to the growing differential volume of the tidal prism that is being filled by the rising tide & 3) the growing differential head. When the magnitude of the draft force is large enough to overpower the tension in the rigging, the gate closes. When tuned properly, the tension regulator in the control mechanism increases the tension as the gate closes, thereby preventing the gate from slamming shut.

It's a bit counter-intuitive, but the tide gate closes very consistently with little variability regardless of the variations in the tides. If there is a large difference between the low tide and high tide, a slightly greater differential head (for a given water level) may develop during the rising tide and the tide gate will close when the upstream water level is an inch or two lower than normal. If the difference between the low tide and the high tide is minimal and/or the high tide is only slightly higher than the normal closing elevation, the flow (for a given water level) is reduced and the gate will stay open and allow water levels that are a few inches higher than normal. This only happens sporadically – a few times a year. When this does happen, the flood tide is on the verge of cresting when the gate closes, so the water level will fall very soon after the tide gate closes.

At the four locations where tide gates have been retrofitted and are operating with the VBFG™ mechanism, the amount of variability in the water level when the gate closes is reasonably small (much less than one foot) and inconsequential.

Pros:

- Extremely durable heavy duty 316 stainless steel[31] and copolymer gate leaf.
- Remarkably simple control mechanism with very reliable operation.[32]
- It will work at any site.[33]
- The tide gate is either wide open (80-90 degrees from the headwall) or fully closed.
- Does not require any outflow to open. The rigging pulls the gate open when there is no seating head.
- Debris rarely (never?) hangs up on the open tide gate.
- Very minimal head loss.
- Fail-safe unattended operation. If any part of the control mechanism breaks, the flap gate simply opens and closes and does not allow backflow.
- Much less expensive than other more complicated tide gates.

Cons:

- Very minor variations in the upstream water surface elevation at which the tide gate closes.[34]

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[30] The mechanism can be used for light-weight top-hinged flap gates as well. A top-hinged fiberglass flap gate at Fornsby Creek was retrofitted with the VBFG™ control mechanism in November 2009. However side hinged flap gates are preferred.

[31] 304 Stainless Steel may be used in fresh water locations to reduce fabrication costs.

[32] The four operating side-hinged tide gates retrofitted with this control mechanism have been operating unattended with minimal intervention for nearly one year as of December 2009.

[33] No outflow is required for the tide gate to open on a falling tide. It is therefore immune to Tide Gate Entropy Death. (See www.jueltide.com for information on Tide Gate Entropy Death.)

[34] The amount of variation depends on the tidal prism of the site. To date, the variation is minimal and inconsequential at all of the tide gates using this control mechanism.

Appendix E

Other Information

- **November 29, 2010 Meeting Record**
- **Mill Creek Terrace Subdivision Plat**

URS

Memorandum

Date: December 6, 2010

To: File

From: Fred Whitley, PE, URS Corporation

Subject: **Phoebus/Mill Creek Terrace Drainage Study- Meeting Record**

On 11/29/10, there was a meeting at the America Legion Hall in Phoebus with some of the residents who live along Mill Creek Terrace and on Willard Avenue to discuss their past street/yard flooding observations in their neighborhood and possible solutions to mitigate the flooding in that area. In attendance were:

Ann Donovan	20 Mill Creek Terrace
Ed Alzarian	12 Mill Creek Terrace
Jan/Joe Furneyhough	10 Mill Creek Terrace.
John Lowe	310 S. Willard Avenue
Kevin Gallagher	City of Hampton, Public Works Dept
Jim Turner	Phoebus Improvement League, executive director
Brad Alger	URS consultants
Fred Whitley	URS consultants

Jim Turner hosted the meeting and he advised the attendees that , as a result of the November meeting with the residents and the city staff about the drainage problems in their neighborhood, the city had hired URS to study the drainage in the area and to make recommendations on improvements that would mitigate the flooding. The residents then talked about the significant rainfall flooding that had taken place in the late summer, generally within the cul de sac at the end of Mill Creek Terrace, which overtopped the curbs and extended into the yards on either side. S Willard Avenue also flooded in front of # 312. A number of photos of the flooding were provided from this storm event.

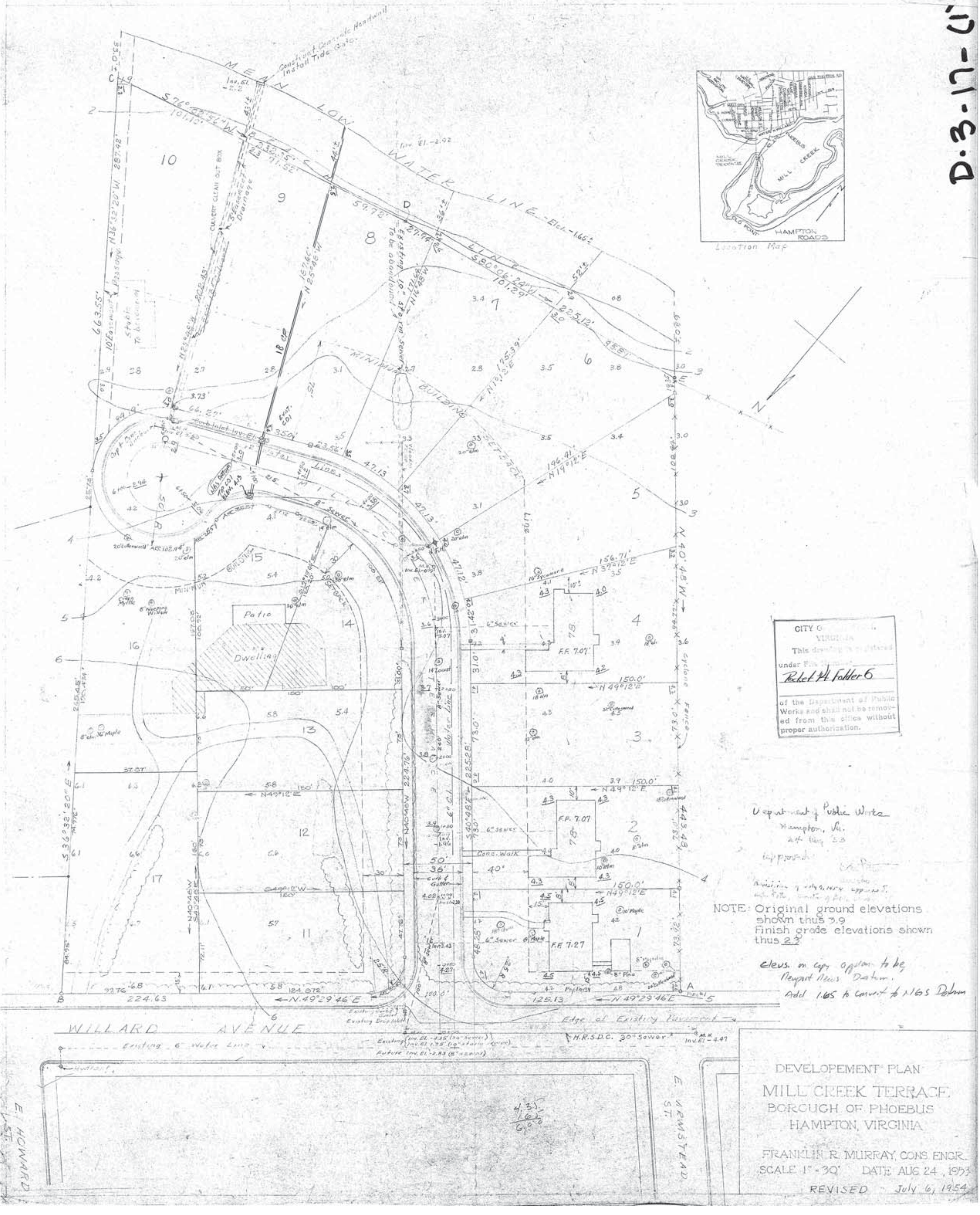
There have been a number of other street/yard flooding events in that area over the years, most of which were caused by a combination of heavy rainfall and elevated tides from Mill Creek. The residents reported flooding incidents where the tidal waters would back up into the storm drain system, and flow out of the curb inlets into the street (even when there was no rainfall). They observed that in a rising tide situation, this back up from the storm drain was occurring first, before the tide would rise over their bulkheads and flood their yards/streets from Mill Creek. They acknowledged that the area was "at the mercy" of Mill Creek in an extremely high tidal flooding event, given the area's relatively low elevation, but they felt there should be some way to prevent flooding in lesser storm/tidal events and a way to speed up the draining of flood waters from the streets, after a storm/ higher than normal tide. The residents also reported a concern about flood waters on the adjacent Wanchese property which were slow to drain away and which may be backing up into Mill Creek Terrace. There was concern expressed about debris in the area contributing to slow moving drains, either from yard waste (leaves, limbs, etc), or manmade materials stored in yards and/or on the Wanchese property.

The following ideas for mitigating the flooding were discussed by the group, and these will be included in the upcoming drainage study along with some analysis and recommendations on the most cost effective options:

1. Encourage better housekeeping practices in the area to reduce the risk of storm drainage blockages from yard debris/stored materials.
2. Clean/maintain the 2 existing drainage outfall pipelines (during the last flooding incident, it had been discovered that the Mill Creek Terrace outfall had been blocked by concrete- this has now been fixed by the city)
3. Improve the existing drainage on the Wanchese property to speed up the run off of water from that property (and thereby possibly reduce flooding on adjacent properties)
4. Replace and/or upsize the existing drainage outfall pipes as needed (the Willard Ave outfall is in questionable condition and it may be located under one of the houses- URS will check to see what intensity storm the existing outfalls can handle)
5. Install tide gates on the storm drain outfalls in Mill Creek (the city is concerned about potential operation and maintenance problems with tide gates-it was suggested the Ft Monroe tide gates may be a good example to consider- the city would like an accessible structure by the gate to allow for easier debris removal). Residents indicated they would be open to assisting the city with the operation/maintenance of a tide gate, if needed.
6. Install additional outfall pipelines from Mill Creek Terrace and/or S. Willard Ave to Mill Creek, (and/or provide additional curb inlets, if needed -some residents believe there was a drainage outfall at one time from S. Willard Ave to Mill Creek along the vacant lot on the southwest side of the Mill Creek subdivision- this lot is currently for sale and is owned by a "Mr. Ping"- URS will check to see if there is a drainage easement across this lot)
7. Raise the portions of the roadways that typically flood.
8. Construct a low earthen levee along the shoreline of Mill Creek to block tidal waters (this creates other issues such as how to drain rear yards behind the levee, what rear yard improvements would be displaced by a berm, and how to access docks- stairs would be required over the berms)
9. Provide portable pumping equipment to speed up the drainage of flood waters from the streets (the residents even indicated they might be willing to set up and operate this equipment)
10. Construct a permanent storm water pumping station (it was acknowledged by all at the meeting that this option was too expensive to even be considered further)

In order to explore these ideas further, the city has authorized URS to first perform an elevation survey of the area. The survey work is expected to begin the week of December 6th. Area residents agreed to alert their neighbors about this pending survey work. Once the survey work is complete, URS will conduct its analysis and confer with the city on its findings. URS will also determine permitting requirements for the various options. A preliminary drainage report will then be prepared and a briefing will be conducted with area residents on the draft recommendations. Following feedback from the residents and the city staff, a final report will be prepared for use by the city in programming drainage improvements in the area, subject to available funding. The time frame for the study is approximately 60 days.

cc: Jim Turner, Phoebus Improvement League
Kevin Gallagher, City of Hampton
Pat Ray, City of Hampton
Chuck Fleming, City of Hampton
Brad Alger, URS Corporation


D-3-17-(1)
Location Map
MILL CREEK
HAMPTON ROADS
MEAN LOW WATER LINE - Elev. -1.65±
Construct Concrete Headwall Install Tide Gate
CULVERT CLEAN OUT BOX
18 C.I.P.
MINIMUM BUILDING SETBACK LINE
MILL CREEK TERRACE
Water Line
8" Sewer
6" Sewer
Patio
Dwelling
Conc. Walk
Curb & Gutter
F.F. 7.07
F.F. 7.27
Cyclone Fence
WILLARD AVENUE
Existing 6" Water Line
Edge of Existing Pavement
H.R.S.D.C. 30" Sewer
E. ARMISTEAD ST.
E. HOWARD ST.
CITY OF HAMPTON, VIRGINIA
This drawing is registered under File Number
Pocket H Folder 6
of the Department of Public Works and shall not be removed from this office without proper authorization.
Department of Public Works
Hampton, Va.
NOTE: Original ground elevations shown thus 3.9
Finish grade elevations shown thus 2.3
Elevs. on copy appear to be Newport News Datum.
Add 1.65 to convert to MLGS Datum
DEVELOPEMENT PLAN
MILL CREEK TERRACE
BOROUGH OF PHOEBUS
HAMPTON, VIRGINIA
FRANKLIN R. MURRAY, CONS. ENGR.
SCALE 1" = 30'
DATE AUG. 24, 1953
REVISED July 6, 1954

City of Hampton

URS Corporation
11658017